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TESIS DOCTORAL

Essays in modelling entry decisions in differentiated product markets

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Introducción, Resumen y Conclusiones

La industria del automóvil ha experimentado un proceso de continua evolución desde sus inicios a principios del siglo XX. La calidad del producto ha mejorado sensiblemente y al mismo tiempo el grado de diferenciación, medido a través del número de variedades o modelos, ha sufrido un incremento espectacular. De una industria caracterizada por firmas nacionales produciendo grandes cantidades de unos pocos modelos hemos pasado a otra en el presente donde grandes multinacionales ofrecen una gran variedad de productos en el mundo entero. El proceso de globalización ha servido para ampliar el número de potenciales clientes, facilitando la investigación y desarrollo de nuevos productos aprovechando la mayor escala operativa. Sin embargo, también ha inducido la aparición de estrategias de gestión de producto a escala nacional. Ambas consumen una cantidad notable de recursos. La industria del automóvil es una de las que más dedica a investigación y desarrollo. Pero además debe hacer frente a costes fijos de entrada en los diferentes mercados nacionales y afrontar el coste de introducir nuevos productos. La inversión anual en publicidad, o el esfuerzo por construir y mantener una red de distribuidores dan una idea de la enorme cantidad de recursos que las empresas deben invertir para comenzar a funcionar en un mercado y atraer la atención de los consumidores.

Esta tesis estudia las decisiones de entrada o comercialización de nuevos productos en mercado español de automóvil, el quinto de Europa con unas ventas anuales de mas de treinta mil millones de euros, desde diferentes perspectivas. El número de modelos de coche se duplica durante la década de los noventa. La alta tasa de entrada hace que este período sea idóneo para entender los factores que determinan las decisiones de introducción de producto. Se hace uso de una base de datos única con información acerca del volumen de matriculaciones y características para analizar diferentes aspectos concernientes a las decisiones de entrada. La tesis se organiza en tres capítulos que consisten en una introducción descriptiva y dos artículos que enfocan el problema de entrada desde diferentes perspectivas y en un grado de complejidad creciente. Los artículos han sido incluídos en su integridad y por ello existe un cierto solapamiento entre los capítulos.

El capítulo dos presenta una descripción del mercado del automóvil español utilizando la información de la base de datos así como otras fuentes alternativas. El objetivo es, en primer lugar, describir el proceso de entrada y salida y la evolución de precios y características en el mercado español. Todos los segmentos del mercado muestran altas tasas de entrada. Ésto se debe tanto a la entrada de nuevas marcas como a las decisiones de reemplazamiento de producto de empresas ya establecidas. Los precios tienden a crecer, así como la calidad media de los coches. En segundo lugar, este capítulo proporciona evidencia que muestra cómo las decisiones de introducción de producto tienen lugar a nivel de mercado nacional. Este resultado se obtiene a través de un análisis comparativo de los principales mercados europeos. Aparentemente, aunque las empresas llevan a cabo su actividad de investigación y desarrollo a nivel global, las decisiones de introducción de un mismo producto difieren entre países. La entrada en mercados nacionales está en parte determinad por las condiciones de la demanda. Por ello se puede distinguir entre decisiones de investigación y desarrollo con escala mundial y la comercialización final de los productos que se deriven de esa etapa, decidida a nivel nacional. Este capítulo ofrece una justificación básica para el resto de artículos de la tesis puesto que justifica la idoneidad de los datos para analizar decisiones de comercialización frente a decisiones de investigación y desarrollo, que se encuentran fuera del alcance de esta tesis.

El capítulo tres presenta un modelo estático de entrada por parte de empresas monoproducto. Constituye un acercamiento inicial al problema. Un nuevo producto es introducido cuando el beneficio variable es más grande que el coste fijo de entrada. Este coste varia con el segmento en que se produce dicha entrada. A partir de las condiciones de primer orden de la maximización de beneficios se puede obtener una expresión para los beneficios variables como función de las cuotas de mercado y una serie de parámetros. Para racionalizar las diferencias observadas entre productos que observamos como igual de rentables se introduce un shock normal idiosincrático. Esto permite la estimación de los parámetros de la función de beneficio utilizando un modelo Probit de entrada en función de cuotas de mercado. Esos parámetros se pueden utilizar para calcular el beneficio de cada producto y la media por segmento. El principal resultado de este artículo consiste en mostrar la relación positiva entre entrada y rentabilidad, algo esperable, y que además las empresas prefieren introducir sus productos en segmentos en los que la variabilidad de los beneficios a lo largo del tiempo es menor.

Este artículo presenta algunas limitaciones. Entre ellas está la naturaleza monoproducto de las empresas, obviando la naturaleza multiproducto de las marcas de automóvil. Esto implica que las estrategias de proliferación de producto no se incluyen dentro del análisis. Una crítica más general puede hacerse debido al uso de un modelo estático en dos etapas. Este tipo de modelo ignora el hecho de que aunque los costes de entrada se paguen una sola vez, son recuperados en varios períodos. Estos modelos presentan también dificultades para incorporar la interacción futura entre agentes, principalmente en decisiones de entrada y salida.

No obstante, los modelos de teoría de juegos de elección discreta han sido el estándar para acercarse al problema de entrada durante mucho tiempo y, a pesar de sus limitaciones, aún pueden ofrecer algunas intuiciones sobre el proceso de entrada. En este caso, como se ha señalado más arriba, los resultados sugieren que la entrada tiene lugar en segmentos con beneficios en media mas elevados y con menor varianza.

Estas limitaciones son superadas en el capítulo cuatro. El modelo estático, habitual hasta hace poco en la literatura sobre entrada, es sustituído por un modelo dinámico de entrada en un oligopolio, siguiendo desarrollos recientes en la materia. La unidad de decisión es la empresa multiproducto, que cada período decide sobre la entrada y salida de sus productos en diferentes segmentos, a continuación decide si modificar sus características y finalmente compite en precios. Todas las empresas toman simultaneamente cada una de estas decisiones secuenciales con el objetivo de maximizar el valor descontado de sus beneficios futuros. El artículo se centra en el estudio de las decisiones de comercialización, sin considerar decisiones de investigación y desarrollo. Esto equivale a asumir implicitamente que existe una etapa previa de I+D (al nivel global de la industria) de la cual una serie de productos resulta técnicamente factible. Sobre ese conjunto de productos la empresa elige aquéllos que serán introducidos en el mercado nacional en la etapa de comercialización. La entrada se produce cuando el coste fijo de entrar es menor que el valor descontado de los beneficios futuros. De igual manera un producto permanece en el mercado cuando dicho flujo de beneficios supera un cierto valor residual recuperable al salir del mercado.

Las empresas establecidas en el mercado tienen presumiblemente unos costes de introducción de producto menores debido a la imagen de marca generada a partir de su actividad pasada, debido a menores costes publicitarios en comparación con empresas entrantes y debido a otros factores que afecten al éxito comercial. En otras palabras, la distribución de costes de entrada varía con el número de modelos comercializados por la empresa. La estimación de las diferencias in esos costes fijos de entrada sirve para cuantificar la dimension de las economías de alcance en la comercialización. La existencia de estas economías de alcance ayudaría a explicar las estrategias de proliferación de producto por parte de empresas multiproducto.

Los resultados confirman la hipótesis, lo cual constituye la principal aportación del artículo. El coste de introducir el primer producto, que de hecho se corresponde con el coste de entrada de la empresa, es significativamente más grande que el coste de introducir el segundo producto. Sin embargo esta ventaja de comercialización parece extinguirse a medida que el número de modelos que posee una empresa aumenta, sugiriendo una curva en forma de U para los costes de entrada como función del número de modelos.

El tema no está resuelto de una manera definitiva. Los modelos dinámicos entrañan dificultades objeto de investigación actualmente. Esto hace necesario introducir algunos supuestos que hacen el models resoluble o estimable. En particular, en este capítulo no se modeliza la etapa de desarrollo del producto, asumiendo que los productos candidato a ser introducidos están, en cierta manera, dados exógenamente. El problema de la potencial multiplicidad de equilibrios no se considera. Se asume que, en el caso de que existan varios equilibrios, los datos son generados únicamente por uno de ellos y, por tanto, que las reglas de comportamiento óptimo se corresponden con ese equilibrio. Un modelo con empresas multiproducto con diferenciación de producto puede hacer que el espacio de variables de estado sea tan grande que el problema se vuelva intratable incluso empleando las metodologías mas recientes. Para reducir el tamaño del espacio de variables de estado se introducen ciertas simplificaciones: El número máximo de empresas está fijado; no se considera la elección de características como tal, sinó que se considera un índice de calidad que resume las características del producto; se hace uso de la naturaleza segmentada del mercado de automóvil para reducir el espacio de competidores de un modelo dado; las decisiones de entrada y salida de la empresa multiproducto dependen del número de modelos de dicha empresa y no de la composición particular de la cartera de productos. Algunas de estas simplificaciones son frecuentes en el trabajo empírico actual en modelos dinámicos. Otras, como la investigación y desarrollo de nuevos productos o la multiplicidad de equilibrios requerirán sin duda más atención en investigaciones futuras.

Abstract

This dissertation focuses on product introduction decisions by multiproduct firms in differentiated product markets. The analysis is applied to the Spanish car market in the 1990's. The dissertation is organized in four chapters. Chapter One provides an introduction to the problem and a summary of the dissertation. Chapter Two provides a descriptive analysis of the Spanish automobile market during the 1990's, which is characterized by high entry rates. Chapter Three approaches the problem of entry from a static point of view. The results confirm the positive relation between entry and profitability and show that firms prefer to introduce their products in segments where the variability of profits is smaller. Chapter Four approaches the problem of entry using a dynamic oligopoly model of competition between multiproduct firms. The main result is that firms have incentives to product proliferation due to the existence of important economies of scope in product entry costs.

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Contents

Chapter 1

Introduction and Summary

The automobile industry has been involved in a process of continuous evolution since its early stages in the beginning of the 20th century. Many quality improvements have been introduced since the first rudimentary machines appeared. At the same time, the degree of product differentiation, measured by the number of models, has exploded. From an industry characterized by national firms producing large quantities of few models, we arrive at present with multinational firms selling many different products worldwide. The globalization process has increased the number of potential customers, facilitating research and development of new products due to the larger scale of operations. However, it has also fostered the emergence of national or regional product management strategies. Both activities consume a large amount of firm resources. The automobile is one of the top industries in the ranking of research. Designing a new model entails large fixed costs. On top of that, firms face fixed costs of entry into national markets and costs of introducing their new products. The figures for annual spending on advertising and the effort to build up a dealers' network give an idea of the large quantity of money that automobile firms need to invest in order to get started, to generate goodwill, and to attract consumers' attention to their products.

Analyzing from different perspectives, this dissertation studies the entry decisions or the commercialization of new products on the Spanish car market, which is the fifth largest in Europe, with annual sales of more than 20 billion euros. The number of car models for sale doubled during the 1990's. This high ratio of entry makes this period ideal for understanding what determines the decisions of product entry. I use a unique data set of car registrations and characteristics to address several aspects of entry decisions. The dissertation is organized in three chapters consisting of an introductory description and two different papers, both of which look at the phenomenon of entry from different perspectives and with an increasing degree of complexity and refinement. The papers have been included in their entirety and hence the chapters show some overlap.

Chapter Two describes the Spanish automobile market using the information from the data set as well as other alternative sources. Its first objective is to describe the entry and exit process and the evolution of prices and characteristics in the Spanish market. High entry rates take place in all segments of the market. This is due to both the entry of new firms and product replacement strategies of incumbents. Prices tend to increase as well as the quality of the cars. Second, it provides evidence on the decisions of introducing new products being made at the country level. This is done through a comparative analysis of the main European markets. It seems that although firms do research at the global level, the implementation of that research leads to differences in the introduction of new products across countries. Entry into national markets is conditioned by demand conditions. Therefore, a clear distinction can be made between the research and development stage at the global level and the final commercialization of those products, decided at the national level. This chapter gives support to the rest of the papers by justifying the suitability of the database for analyzing commercialization decisions as opposed to research and development decisions, which are beyond the scope of this dissertation.

Chapter Three develops a static model of entry by single-product firms. It constitutes an initial approach to the problem. A new product is introduced when the variable profit is larger than the fixed cost of entry. This cost varies with the segment of entry. From the first-order conditions of profit maximization, variable profits can be expressed as a function of market shares and parameters. A normal idiosyncratic shock is added to rationalize differences in decisions from products that we observe as equally profitable. This allows us to estimate profit parameters using a probit of entry on a function of market shares. Those parameters can then be used to compute the profitability of each product and the average profit per segment. The main conclusion of the chapter is that there is a positive relation between entry and profitability and that firms prefer to introduce their products in segments with smaller variability of profits over time.

This paper has some shortcomings. Among them is the single-product nature of firms, which obviates the multiproduct nature of automobile producers. This implies that strategic product proliferation strategies are eliminated from the analysis. A more general criticism can be made about the use of a static, two-stage framework. This ignores the fact that entry costs are paid once but are recovered in several periods, and it also has difficulties in accommodating future interaction among agents.

However, discrete choice game theory models have been the standard way to approach the problem of entry for a long time and, despite their drawbacks, they can still provide some insights on the entry process. In this case, as noted above, the results suggest that entry takes place in segments with a higher mean and lower variance of profits.

These limitations are surpassed in Chapter Four. The static model, which had been the usual approach in the entry literature, is substituted by a dynamic oligopoly model of entry, following recent developments in the topic. The unit of decision is the multiproduct firm, which first decides on the entry and exit of products in different segments every period, then decides whether to modify product characteristics and finally sets prices. All firms simultaneously make each of those sequential decisions with the aim of maximizing their present discounted value. The paper studies only commercialization decisions, and does not consider research and development decisions. This is implicitly assuming that there is a previous R&D stage (at the global industry level) after which a number of products become technically feasible. The firm then chooses those to be introduced in the national market in the commercialization stage. Entry occurs when the fixed cost of entry is larger than the expected discounted value of future profits. Similarly, a product stays on the market when the flow of payoffs exceeds some sell-off value received upon exit.

Firms that are already in the market are likely to have lower product introduction costs because of the stock of goodwill generated from past performance, because of smaller advertisement costs compared to entrant firms, and because of any other factors affecting commercial success. In other words, the distribution of entry costs varies with the number of models owned by the firm. The estimation of the differences in these fixed costs of entry serves to quantify the scope economies in commercialization. The existence of economies of scope can help to explain product proliferation strategies of multiproduct firms.

The results confirm this hypothesis, which is the main contribution of the paper.

The cost of introducing the first product, which is in fact the cost of firm entry, is significantly larger than the cost of introducing the second product. However, this commercialization advantage seems to disappear as the number of models owned by the firm gets larger, suggesting a U-shaped curve of entry costs on the number of models.

The issue is, however, far from being closed. Dynamic models pose problems that are the object of current research. This forces one to make assumptions that help the model to be solvable or estimable. In particular, I do not model the product development stage, assuming that candidates for products to be introduced are somehow given. I am not addressing the potential multiplicity of equilibria. I assume that regardless of the number of equilibria, the data has been generated by the same one and therefore the optimal rules of behavior correspond to that equilibrium. A setting of multiproduct firms with product differentiation can make the state space so large that the problem becomes intractable even when employing recent methodological advances. I have adopted some simplifications to obtain a state space that is not too large: The maximum number of operating firms is fixed; I do not address the choice of characteristics and instead I use a quality index that summarizes product features; I make use of the well documented segmentation of the car market to restrict the space of competitors for a given product; the decisions of entry and exit of the multiproduct firm depend on the number of models of that firm rather than the particular composition of the portfolio of products. Some of these simplifications are common in current empirical work. Others like product development or multiplicity of equilibria surely deserve more attention in future research.

Chapter 2

A Descriptive Analysis of the Spanish Car Market in the 1990's

2.1 Introduction

This chapter provides an overview of the automobile market in Spain during the 1990's. The focus is on descriptive analysis based on my data set and other sources. I look at product turnover and at changes in characteristics and prices over time. The chapter is organized as follows: Section 2 describes the data base, which is used to make a report on the entry and exit patterns in Section 3 and the evolution of prices and characteristics in Section 4. Section 5 presents some evidence from specialized magazines. Section 6 looks at other European markets. Section 7 concludes.

2.2 Data Description

I use a unique data set of monthly registrations of new cars in Spain from January 1990 to December 2000. These data were initially collected by, and first used in Moral (1999)[1], who also provides a thorough description of the data base. It includes information on listed nominal and real prices and characteristics such as car size (length, width, weight, luggage capacity), power (cubic centimeters and horse power of the engine, number of cylinders, maximum speed), fuel consumption, and equipment (dummies for air conditioning, ABS, airbags, central door locking,

[1] The data base here, which runs from January 1990 to December 1996, has later been extended up to December 2000.

electric windows). It also has information on the geographical origin of the brand producing the model. The unit of observation is the car model.

The definition of model is taken as the commercial name from industry sources. Car models often have several variants or subvariants. In the data, a given model denomination is associated with the characteristics of the most popular variant. Therefore, the variation in characteristics over time is due to the variation of the characteristics of the representative variant and not to the change of variant. The number of registrations for a model are, however, the sum of registrations of all variants. We can find alternative model definitions in the literature, for example, based on characteristics (Berry, Levinsohn, and Pakes (1995)). There, a model is represented by some set of characteristics, and when these pass some threshold, a new model is defined, even though both models maintain the same commercial denomination. Both approaches are common in the literature on the automobile industry (see, for example, Brenkers and Verboven (2006)).

Some filters were introduced to exclude super luxury models, e.g., Ferrari or Rolls Royce. Models with fewer than 10 registrations per month are also excluded. Nevertheless, the data set accounts for more than 99.9% of car registrations.

Models are classified in segments and segment definition is taken as granted from industry sources[2]. In particular, I consider the following classification in eight segments: Small-Mini, Small, Compact, Intermediate, High Intermediate, Luxury, Sport, and Minivan. Industry reports show there is a general consensus on the models included in each group.

The typical brand offers several models in different segments. In the data, a brand is just the commercial name of the car manufacturer.

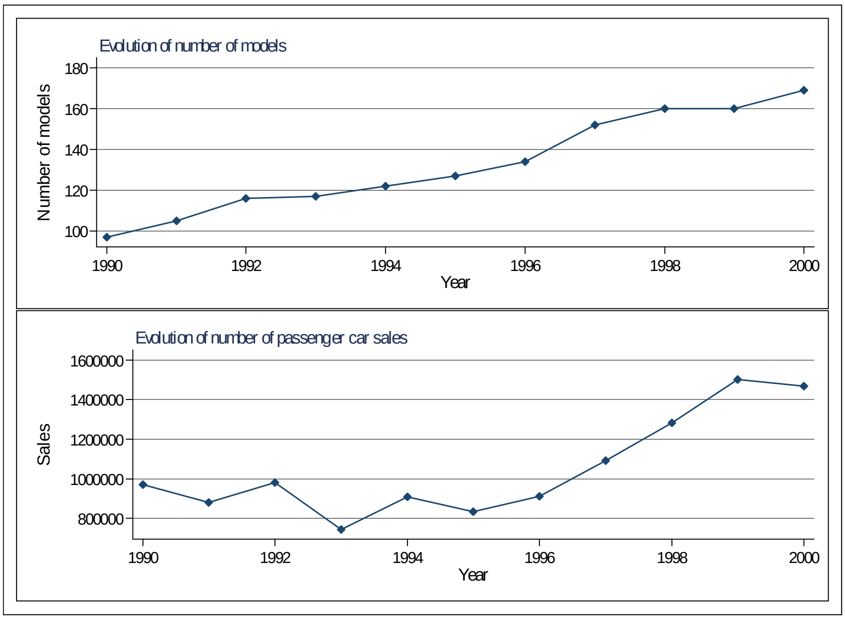
[2] National Association of Automobile and Truck Manufacturers (ANFAC) Annual Report (2006), page 57. Accessible online at http://www.anfac.es . During the 1990's, the Minivan segment was still marginal in Spain, for which reason it was grouped in a unique category that nowadays has split into two, following the consolidation of the segment.

2.3 Entry and Exit

From 1990 to 2000, the Spanish market witnessed a dramatic increase in the number of models: from an initial number of 77 models we end up with 159 by December 2000. The number of models increased constantly during the whole period even though the total number of passenger car registrations and the real GDP per capita remained constant (and even declined) in the first half of the sample period (Figure 1). Therefore, variability of market characteristics like market size or purchasing power does not seem to be enough to explain such proliferation.

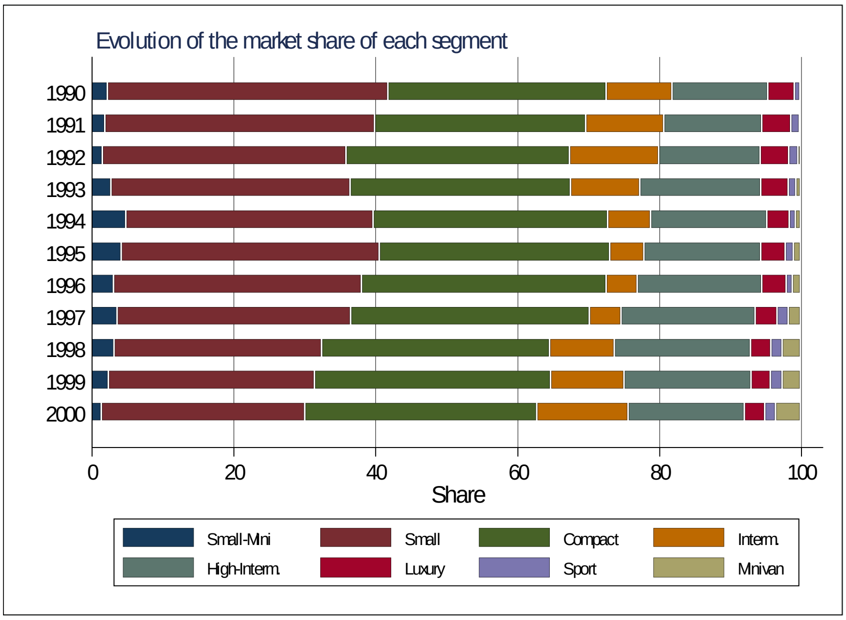
In 1993, a fall in tariffs on imported cars took place. This is a perfectly foreseeable event that has surely had an impact on product introduction by foreign firms. However, Figure 1 shows that in practice entry rates are pretty similar before and after 1993. Therefore, it does not seem that foreign firms were waiting for the tariffs dismantling process to introduce a large number of new models in Spain. The reduction in tariffs can explain only part of the entry process in the Spanish market.

Figure 1:



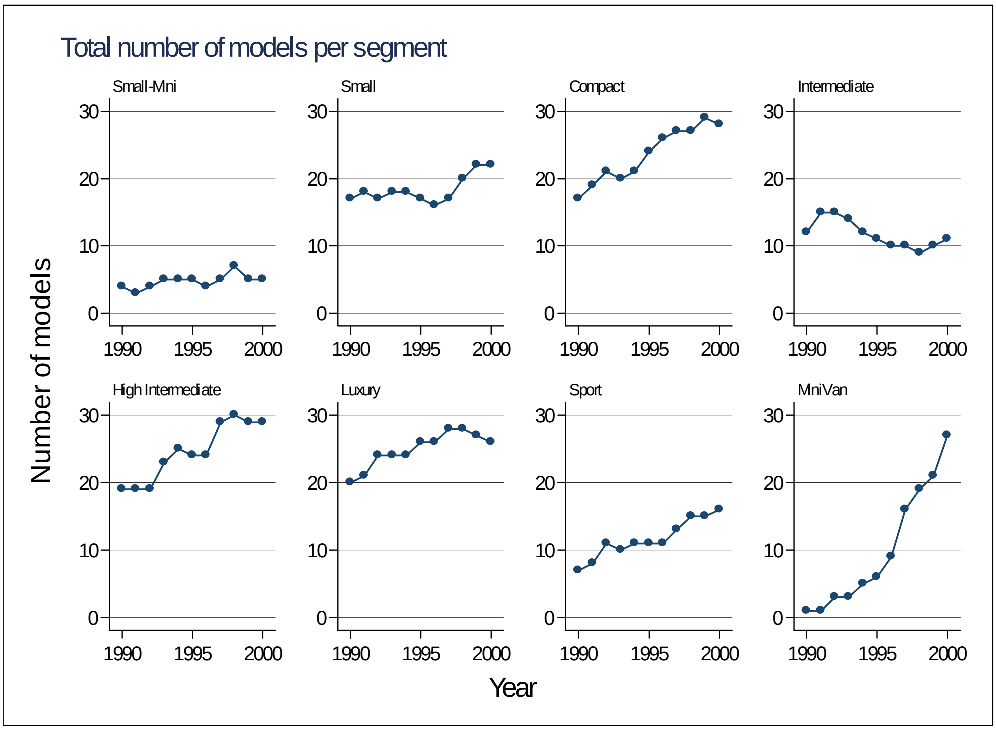
Regarding the segmentation of the market mentioned above, we can say that from the Small-Mini to the Luxury the differences are mainly vertical, i.e., the cars of upper segments are better. The Sport segment has some horizontal differentiation component with respect to High Intermediate and Luxury. Minivans are horizontally differentiated with respect to all other segments. The relative weight of each of them has varied over time (Figure 2). The Small cars lost market share against Compact. High Intermediate and Minivans also increase their shares while Intermediate follow an irregular pattern and Small-Mini decrease.

Figure 2:



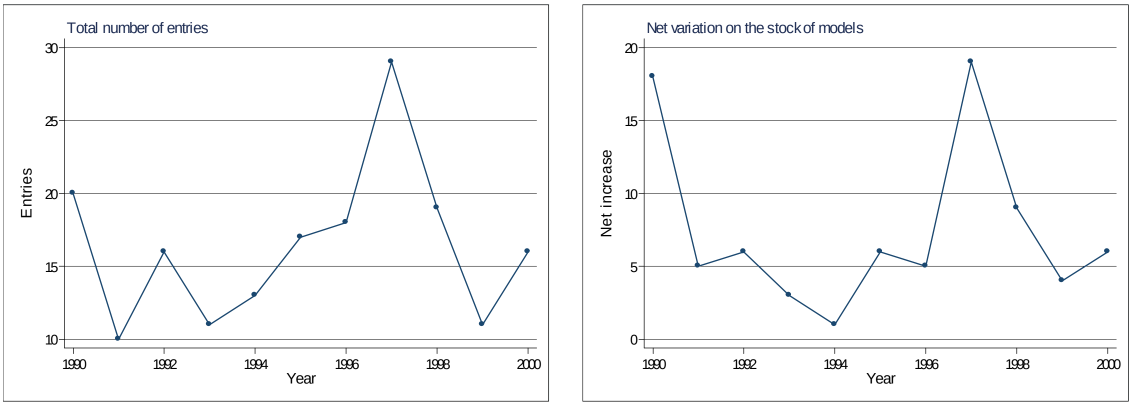
During the sample period, we observe that the increasing trend for the number of products applies to all groups (Figure 3).

Figure 3:



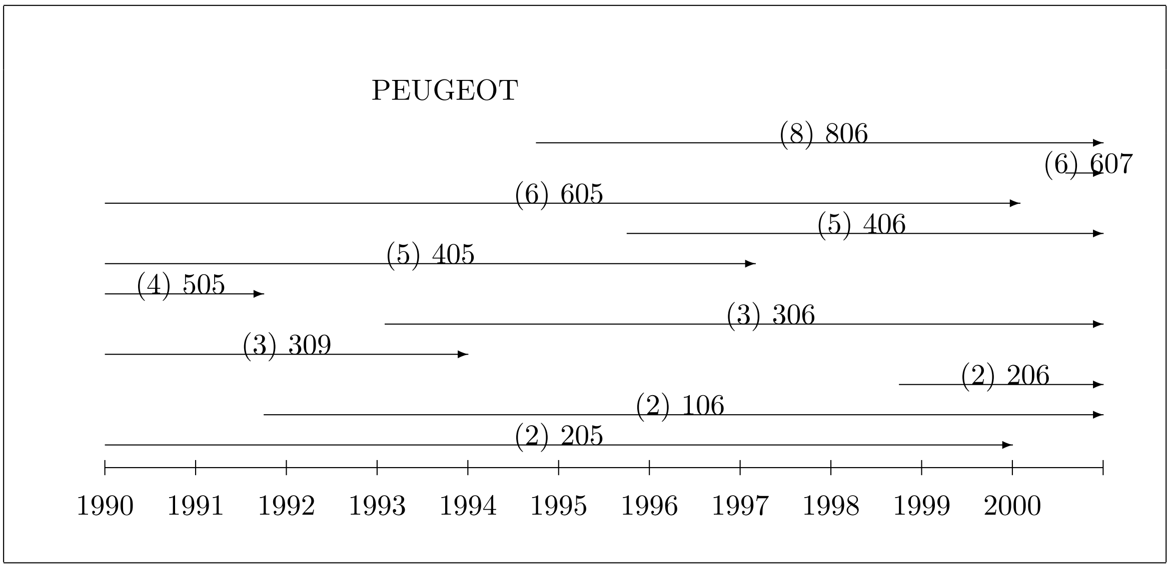
Looking more carefully at the entry and exit process, we see that the net increase in the stock of models is driven mainly by the entries, with exits remaining stable over the sample period. The most remarkable fact is the wave of entries in 1996-98 with its peak in 1997.

Figure 4:



There are two important factors that may justify this intense process of product entry: model replacement and product proliferation. The first factor responds to the behavior of incumbent firms that periodically renew their portfolio of products as a strategic reaction to product introduction decisions by rival firms. During the replacement process, the new product is introduced and it competes for a while with the old one. This is done segment by segment and the duration of the overlapping varies from case to case depending of the relative success between the new and the old product. Figure 5 depicts the whole range of products commercialized by Peugeot between 1990 and 2000 and their life spans. The replacement is almost perfect for segments (in brackets) Compact (3), High Intermediate (5), and Luxury (6). Within the Small (2) segment, we observe longer overlaps due perhaps to the success of the 106. This kind of behavior is common to many incumbent firms.

Figure 5: Example of product proliferation and replacement patterns: Peugeot



The second factor is a consequence of the entry of new firms into the market. These firms usually start with one or two models and, as they consolidate, they introduce more and more products to offer the widest range of models possible. In practice, this implies firms having at least one product in a number of different segments. Product proliferation is also caused by incumbent firms entering new segments. This could be interpreted as a sort of product differentiation strategy intended to reduce the toughness of competition and also as a way to attract new types of customers. In the example above, Peugeot does not introduce a Minivan (segment 8) until the middle of the decade, perhaps as a reaction to other firms that had already entered that segment.

Table 1 gives an idea of the entry and exit activity of incumbent brands. The second column shows the number of brand models in January 1990 and the third column the number of different segments corresponding to those models. The fourth column shows the number of brand models in December 2000 and the next column the number of different segments. The last three columns show the total number of new models introduced during the sample period, the total number of models exited, and the total number of models offered (i.e., the number of initial models plus the total number of entries), respectively. For example, in January 1990, Citroen had three different car models, each of them in a different segment. By December 2000, it had four different models in four different segments. During these eleven years, Citroen introduced five new cars and it discontinued four others, with a total of eight models offered during the sample period. It is clear from Table 1 that most incumbents tend to enter new segments, but also to replace old models in segments where they are already present.

Table 2 provides evidence for firms that enter the Spanish market during the nineties (the date of entry is in the second column). In this case, it is clear that, in relative terms, newcomers introduce many more models than incumbents, most likely in an attempt to catch up.

Product proliferation is therefore quite important during the decade and it is more intensively developed by new brands on the market.

Table 1: Product entry and exit by incumbents

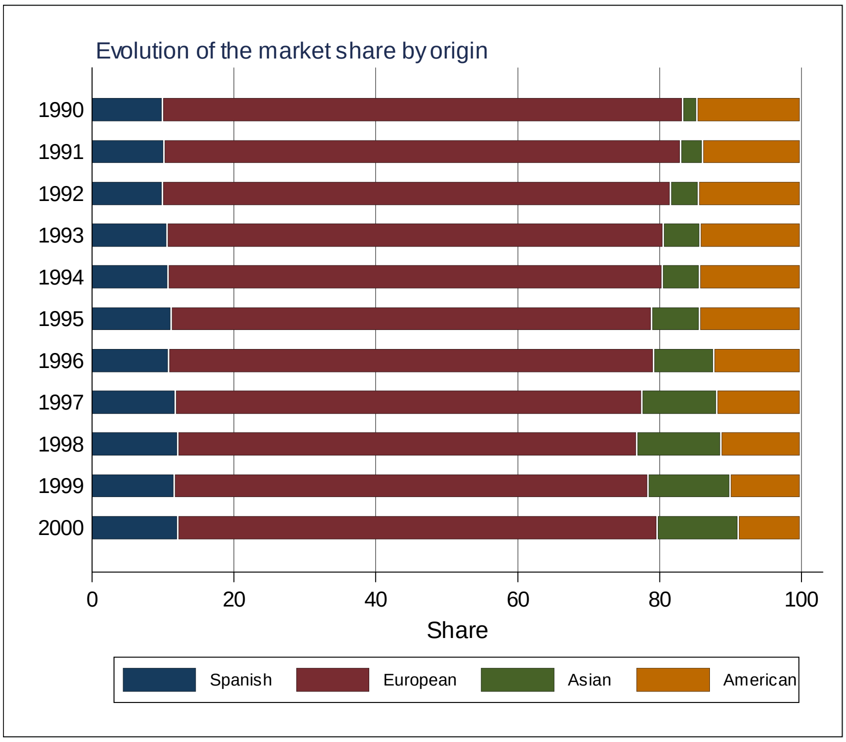
	Initial number of:		Final number of:		Total number of:		
Brand	Models	Segments	Models	Segments	Entries	Exits	Models
Citroen	3	3	4	4	5	4	8
Fiat	4	3	8	6	12	8	16
Ford	5	5	8	6	8	5	13
Mazda	2	2	5	5	4	1	6
Opel	5	4	7	6	7	5	12
Peugeot	5	5	6	5	6	5	11
Renault	6	5	6	6	5	5	11
Rover	4	4	3	3	13	14	17
Seat	3	3	6	5	5	2	8
Toyota	3	2	6	4	7	4	10
Volkswagen	6	5	7	6	5	4	11

Table 2: Product entry and exit by new entrants

	Date of	Initial number of:		Final number of:		Total number of:		
Brand	entry	Models	Segments	Models	Segments	Entries	Exits	Models
Chrysler	Feb. 1992	2	2	6	4	7	1	7
Daewoo	Mar. 1995	2	2	6	5	8	2	8
Galloper	Nov. 1998	1	1	1	1	1	0	1
Hyundai	Jan. 1992	4	4	7	6	9	2	9
Kia	Jan. 1997	3	3	7	3	8	1	8
Mitsubishi	Jan. 1990	1	1	3	3	3	0	3
Subaru	Jan. 1991	1	1	1	1	1	0	1
Suzuki	Jan. 1990	1	1	3	3	5	2	5

Table 2 shows that a large part of the product proliferation effect is due to Asian manufacturers. Indeed, their market share steadily increases over time compared to European and, more significantly, to American manufacturers (Figure 6).

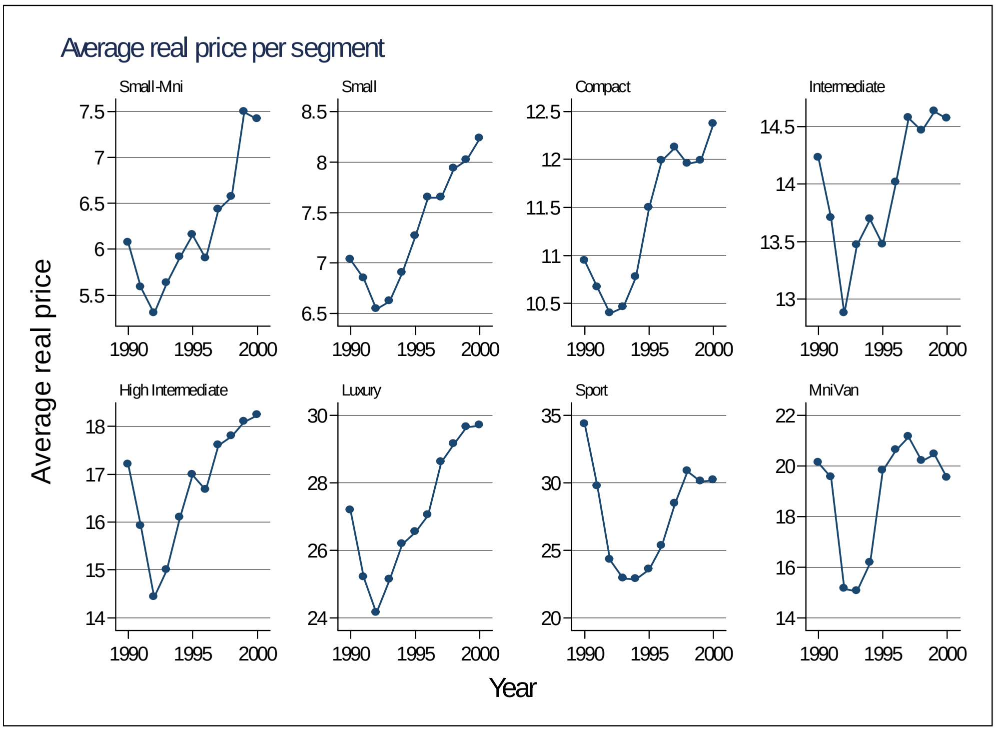
Figure 6:



2.4 Prices and Characteristics

Average real prices tend to increase after an initial period of decline due to the economic crisis in the first half of the decade (Figure 7).

Figure 7:



However, the average quality of cars increases over the period as well, such that quality adjusted real prices remain constant or even fall during the decade. Appendix 1 collects some figures depicting the increase of some selected, representative car characteristics leading the quality change. If we look at averages per segment, we see that the size and weight increase over time, leading to "better" cars (for the Sport segment the feeling is usually the opposite: "good" sport cars are small, fast and powerful). The maximum speed and the power of the engine have also increased over time, although not so steadily. Also, the proportion of cars with air conditioning, anti-lock braking system (ABS) and driver airbag has increased during the whole period. These characteristics have been considered proxies for quality or "luxury" grades of car (e.g., air conditioning in Berry, Levinsohn, and Pakes (1995)) and they clearly show that the quality of all segments has increased, although it increased sooner in the higher-quality segments, as one might expect.

The changes in average characteristics for the Small-Mini and Minivan segments are affected in part by the small number of models, which makes new entries have a large influence on the averages. In the rest of segments, the number of models is larger and the averages show a smoother pattern.

In the second part of the appendix, I report the change in car size, horse power, and maximum speed for some selected models. I pick those three characteristics to keep the exposition simple but the results apply in general to all the characteristics mentioned in the by-segment analysis. I have selected the models from the set of most popular cars in the sample, trying to balance the brands, segments, and brand-origin representation. The main conclusion that can be drawn from those pictures is that quality is also changing over time for specific models. Firms seem to adjust some characteristics of their products from time to time. The rationale for that is to keep track of consumer needs and also to respond to competitors' entry and exit decisions, which affect the average quality of a given model's competitors. Changes are usually small, as we could expect, because if the change needed were very large, the most likely best response would be the introduction of a new model. Finally, the frequency of changes varies from one model to another with no particular pattern by firm or segment: some models change frequently while others do not change at all (at least during the sample period).

2.5 Evidence from Specialized Car Magazines

This section summarizes the casual evidence obtained from automobile magazines on the issue of changes in characteristics. It is based mainly on news taken from the online car magazine of the Spanish newspaper "El Mundo"[3]. I have reviewed several editions from the last two years. Although these two years are not part of my

[3] Available at: http://www.elmundo.es/elmundomotor/index.html . pdf copies of the news and reports used for this section are also available from the author. I can provide a translation into English for those which are in Spanish.

sample period, it does not seem difficult to assume that the same kind of behavior may have happened in the past.

Firstly, there is strong evidence of segmentation in the market. When a new models arrives, it is immediately associated with a set of competitors and this becomes public information for both consumers and producers[4]. This fact gives support to particular demand modelling strategies such as Nested Logit.

Secondly, it is easy to find news related to variation of characteristics. In general terms, firms tend to modify the design of the car and/or its technical characteristics. Usually those changes in characteristics are small but relevant. They are also advertised and diffused and they entail some costs of adjusting production. Many brands behave like that. I have collected evidence for several models, among them the Ford Mondeo, Volkswagen Golf, Renault Twingo, Skoda Fabia, Volvo V70, Toyota Avensis, and Opel Astra. Therefore, there is evidence on changes in the quality of cars over time, and these changes are intended to attract demand and to relaunch the profitability of an existing model (e.g., the new Renault Twingo).

Finally, we can also find some evidence regarding the level at which some decisions are made. The development of new models is decided at the global industry level. However, the decisions to introduce those new products seem to be made at the regional market level, which in Europe basically coincides with a country. Therefore, conditions of local demand influence product entry and exit decisions, but also the modification of existing products. For example, it is reported that the Volvo V70 was first introduced in the Scandinavian market and would then be progressively introduced in the remaining European countries.

[4]For example, the introduction of the new Renault Laguna taken June 4, 2007: http://www.elmundo.es/elmundomotor/2007/06/04/coches/1180975643.html

2.6 Evidence from European Car Markets

This part looks at the evolution of characteristics in five different countries (Belgium, France, Germany, Italy, and the UK) using a data set available at Frank Verboven's website[5]. Verboven's data set uses slightly different definitions of model but it has information on similar characteristics. For the sake of simplicity, I present here some description of one characteristic (horse power). The evidence from other relevant characteristics is qualitatively the same.

The set of graphs presented in Appendix 2 give an idea as to what is going on. The first two graphs (Figures 18 and 19) depict the entry and exit process for a number of models in each of the five countries. A sample of car models is listed on the x-axis, and the year of entry is on the y-axis. Each country is represented by a different symbol so, for example, the first model (coded as $x = 100$) was introduced in France in 1993 and in other countries in 1994.

Figure 20 shows the dispersion of horse power in each country for a sample of models. This graph must be read as follows: on the x-axis we have a sample of models listed from 1 to 30; horse power is on the y-axis. Take, for example, model number fifteen and look at the vertical line passing through $x = 15$. If there is more than one dot over the line, this means that this characteristic has changed at least once. If characteristics did not change at all, then there would be only one dot per model.

Figure 21 plots the evolution of horse power for a sample of models. This graph is read as follows: the year is in the x-axis and horse power in the y-axis. Take the year 1995 and consider a vertical line passing through it. If there is more than one dot over that line, this means that horse power in 1995 was not the same in the five countries, i.e., the characteristics of cars are different across countries even for the

[5] http://www.econ.kuleuven.be/public/NDBAD83/frank/cars.htm

same model.

The graphs suggest the following:

- Entry is usually not simultaneous in all countries. Gaps of two or three years across countries at the moment of entry are frequent, especially for non-European producers. Those gaps are wider and even more frequent for exit decisions. These two facts suggest that entry and exit are influenced by national market conditions.
- Characteristics change for a large proportion of models in all countries. Notice that if characteristics did not change at all, we would have a graph of a curve instead of a cloud. Computations from the data base induce us to think that there is a rate of change of 50% of the observations overall (not so different from my data).
- The change is not always the same in all countries and evolution by country does not overlap.
- The amount of the change in characteristics is not large.
- I can capture changes in observed characteristics (engine, size, etc.) but I cannot capture changes in design. The important thing is that changes are almost always in both observed and unobserved characteristics.

2.7 Conclusion

From the descriptive analysis above, we can conclude that the Spanish automobile market shows a dramatic increase in the number of products that corresponds mainly with firms' product proliferation strategies, although there is some influence of product replacement behavior. Firms introduce new products, apparently to keep track of consumer needs, but they also try to increase the life span of current products by modifying their characteristics. The empirical evidence suggests that those decisions are made on a regional / national basis, rather than at the global market level. Therefore, the main question to be solved is to explain how and why firms find it profitable to expand their range of products by estimating product entry costs.

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Appendix 1: Evolution of Car Characteristics

By Segment

Figure 8:

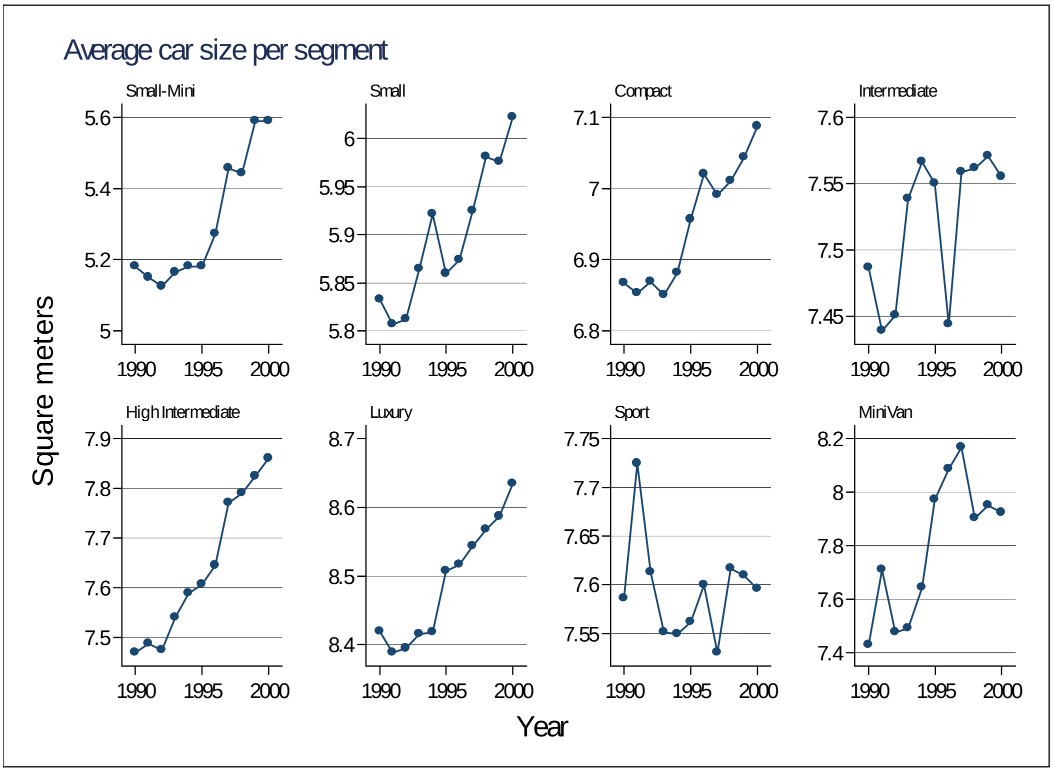


Figure 9:

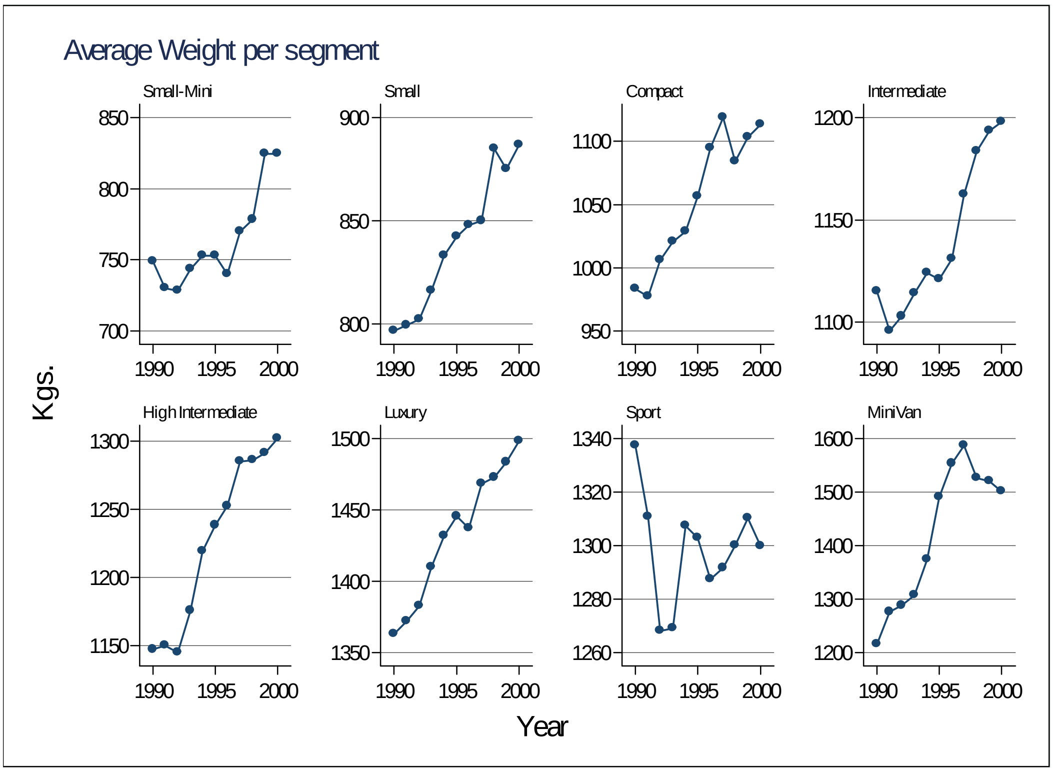


Figure 10:

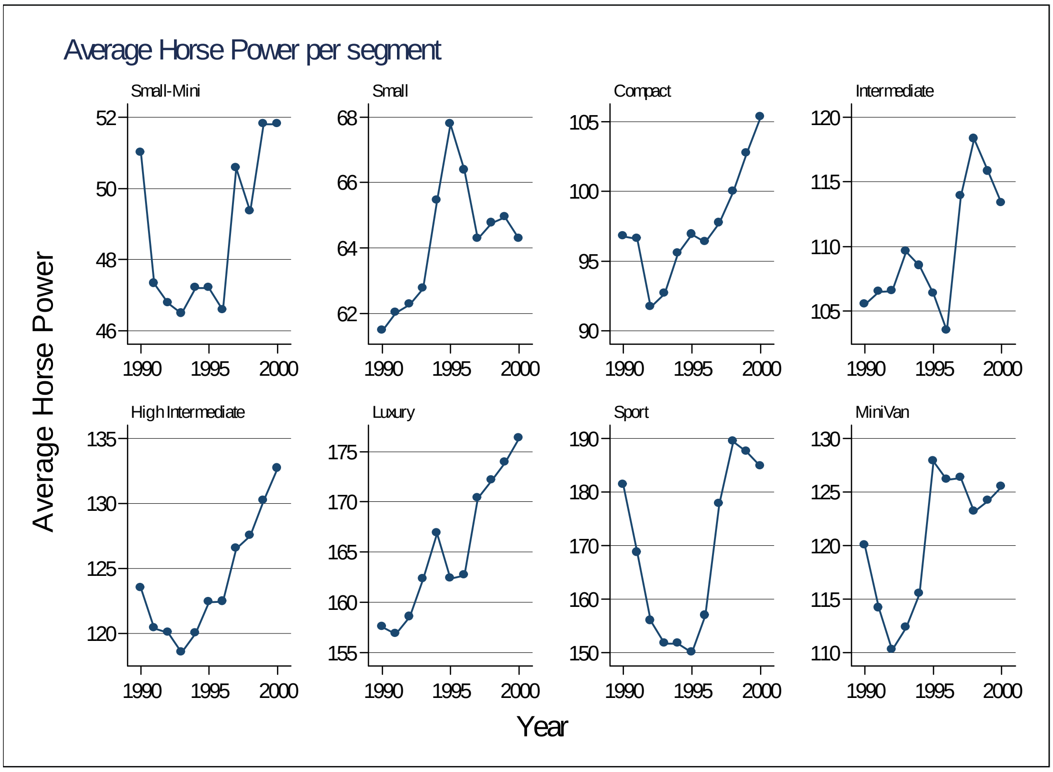


Figure 11:

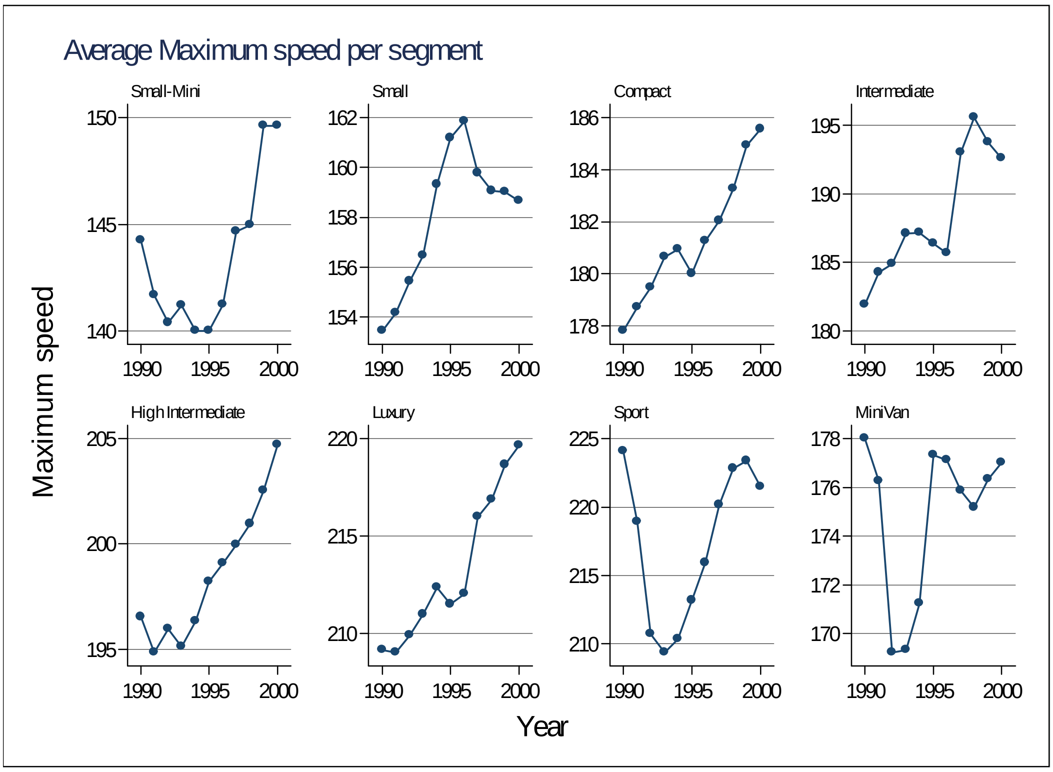


Figure 12:

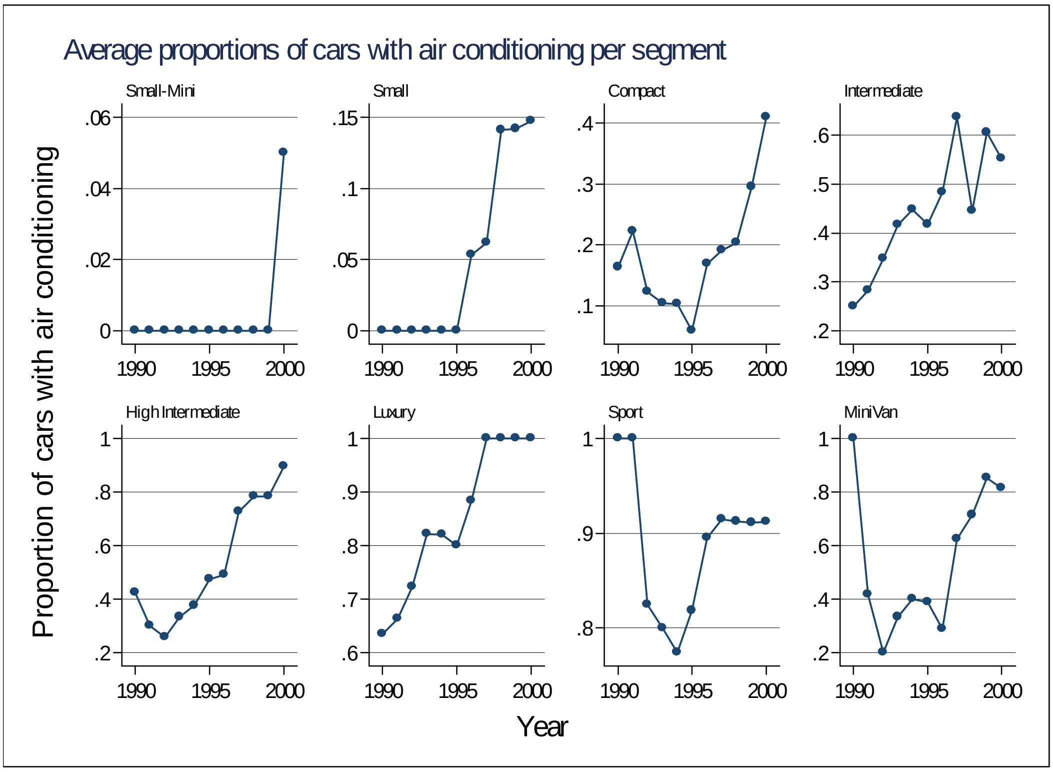


Figure 13:

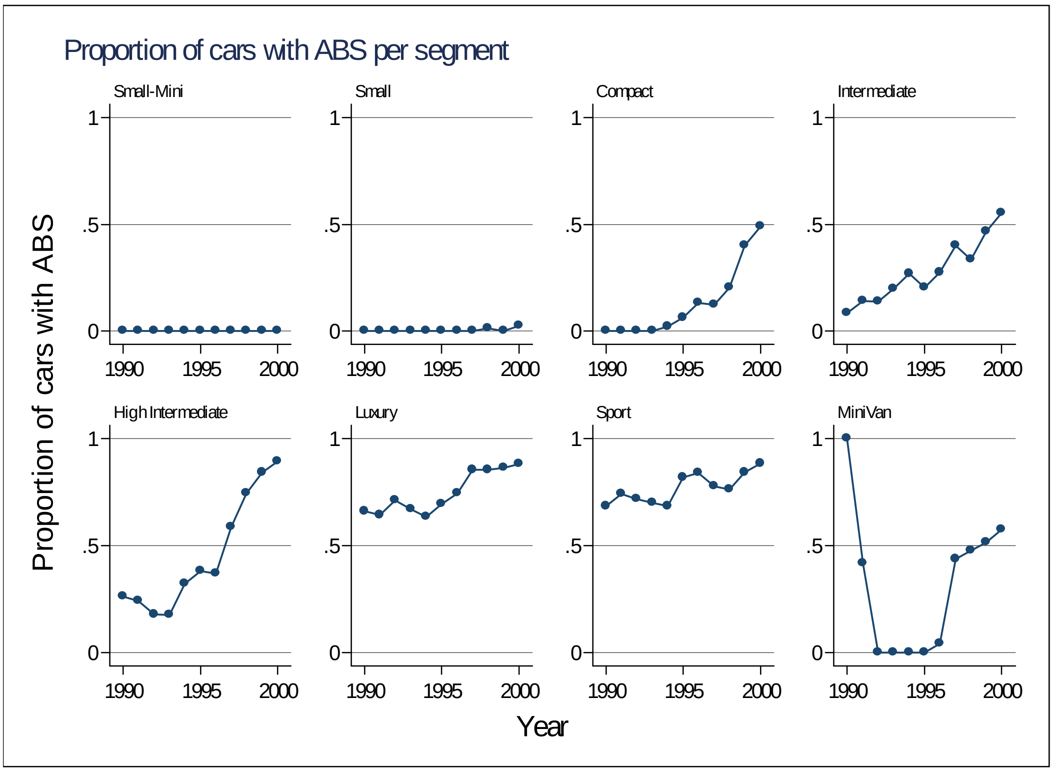
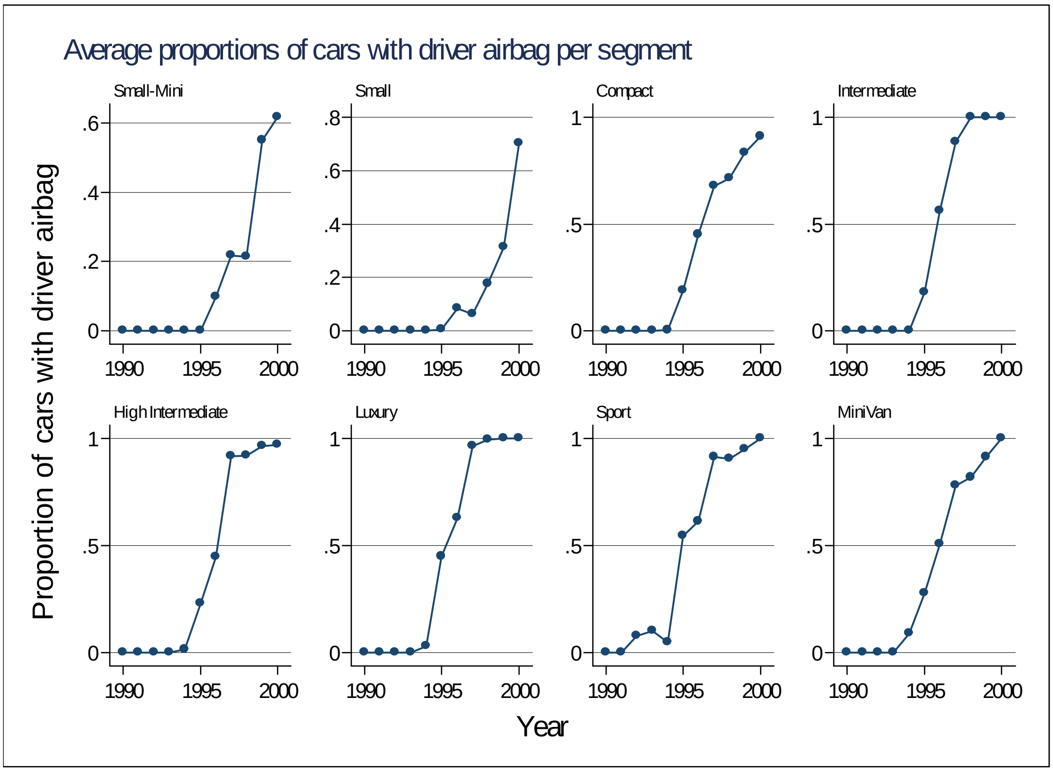


Figure 14:



Selected Models

Figure 15:

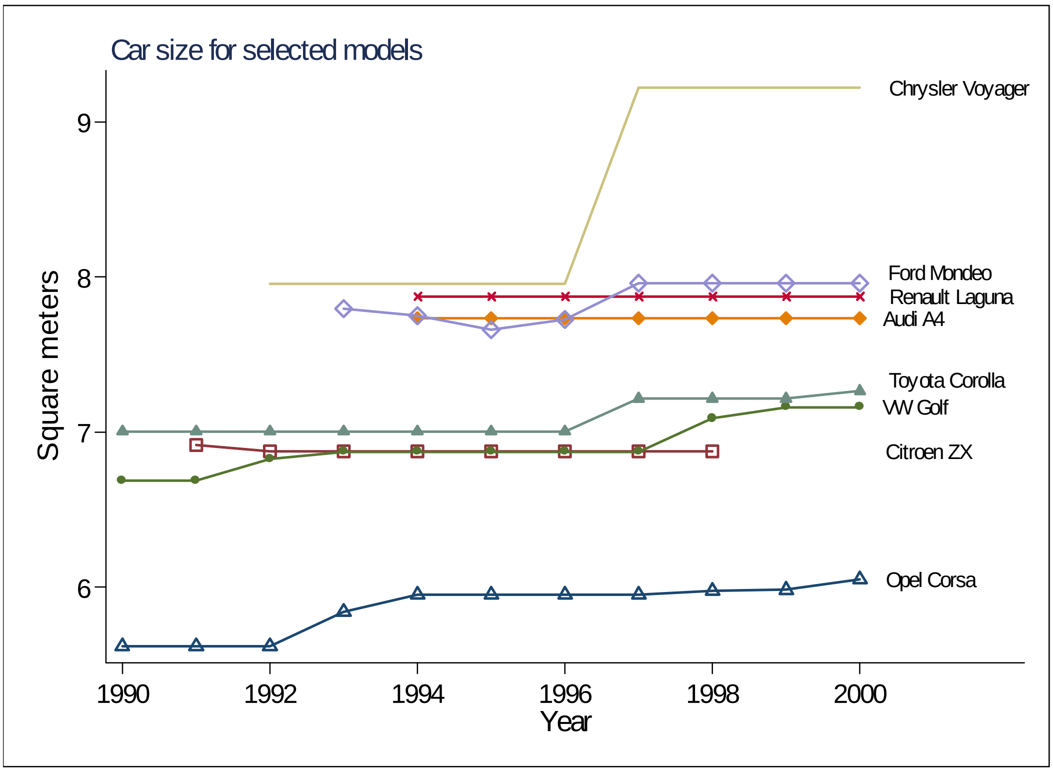


Figure 16:

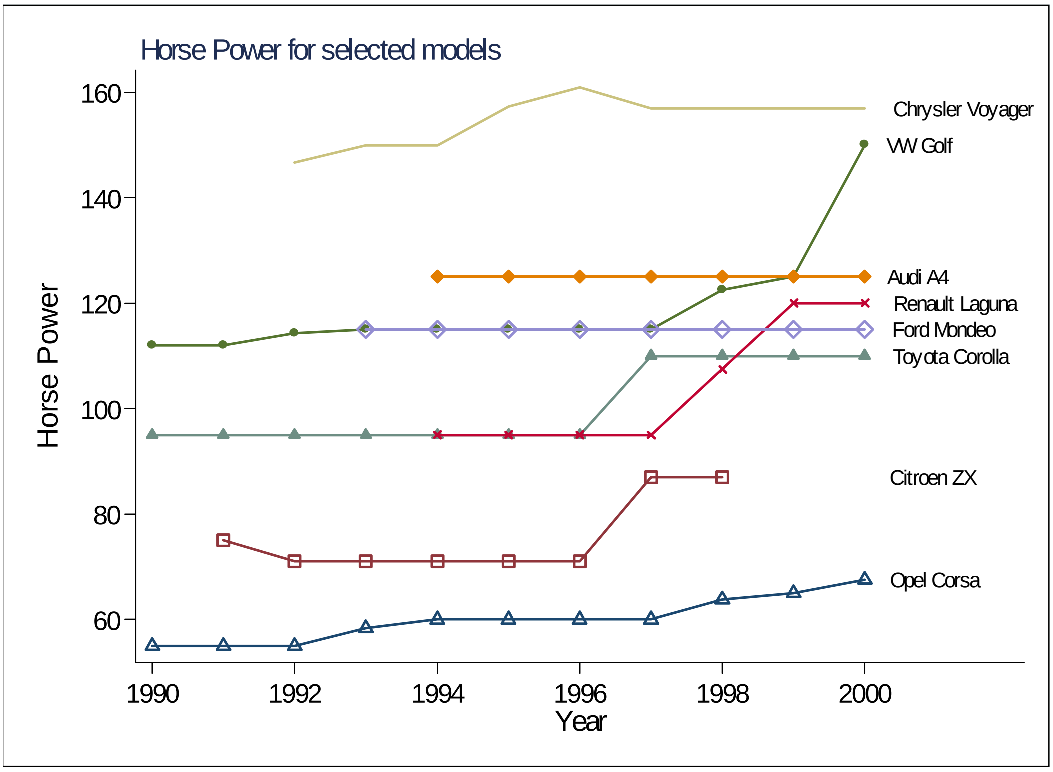
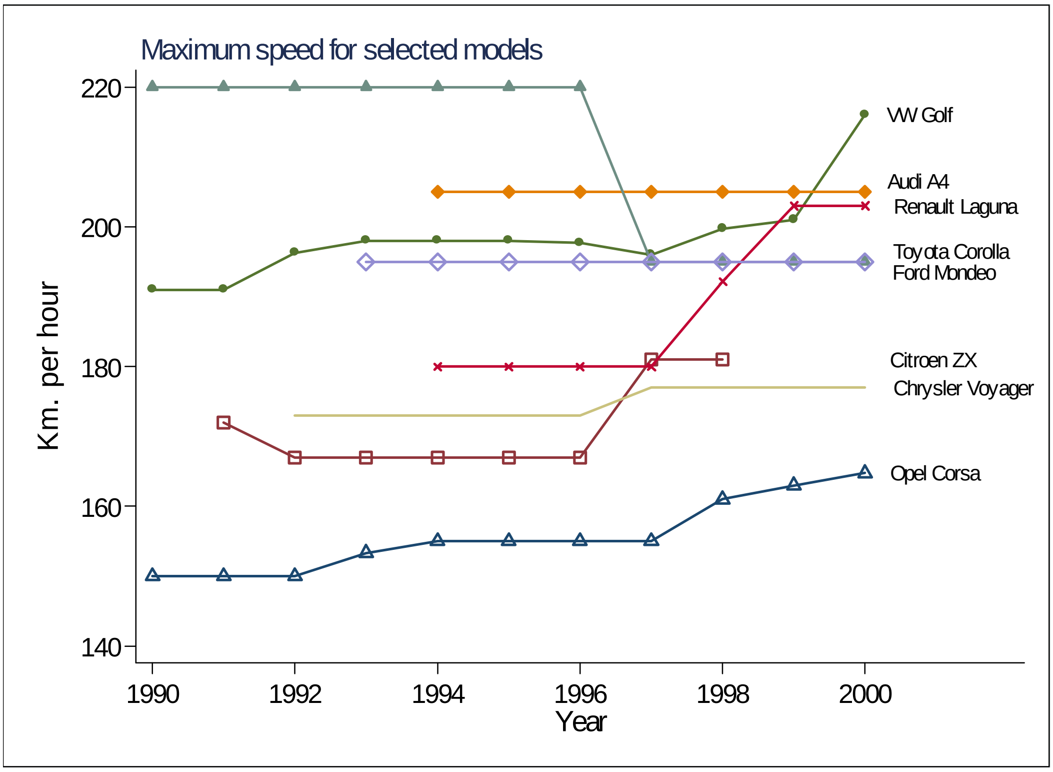


Figure 17:



Appendix 2: Figures for European Car Markets

Figure 18:

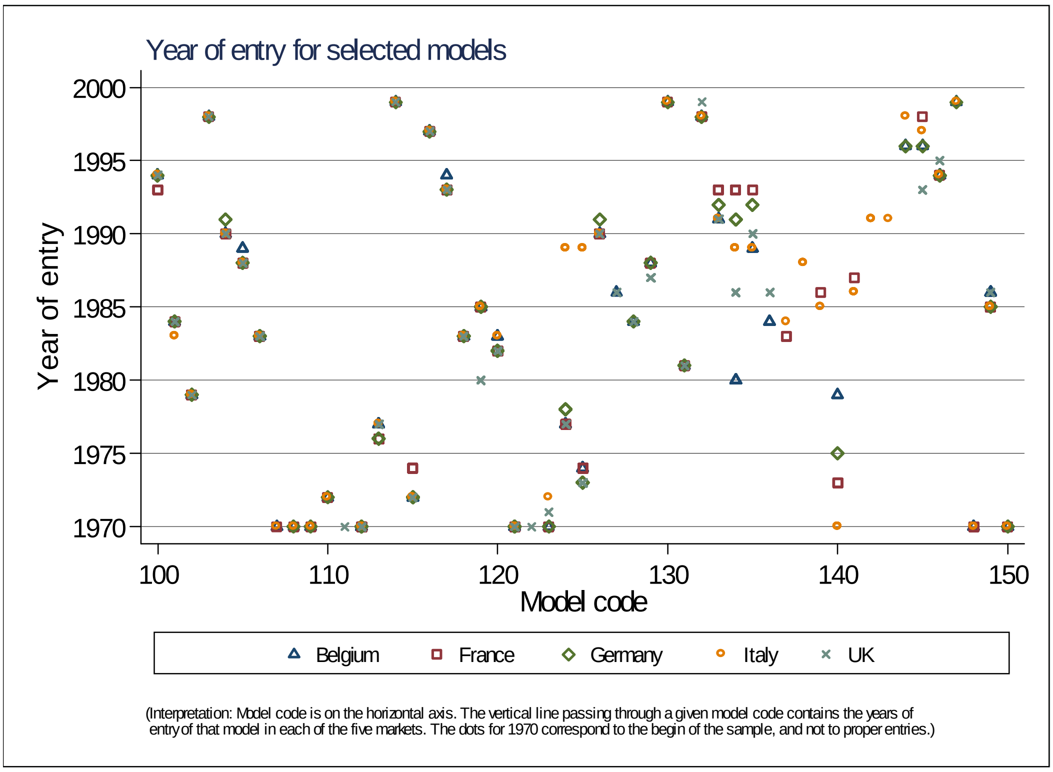
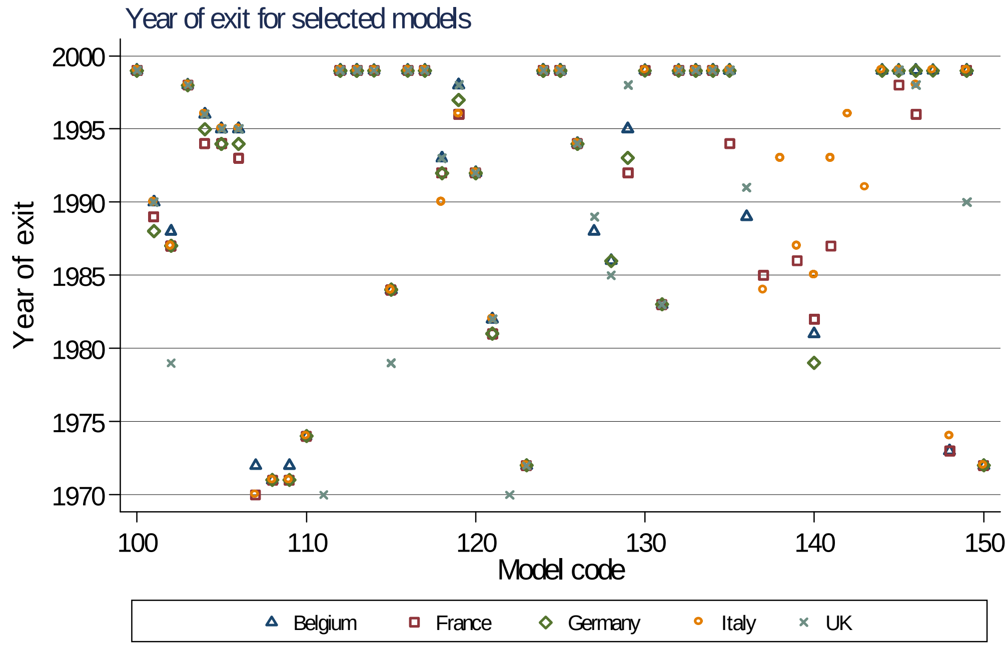
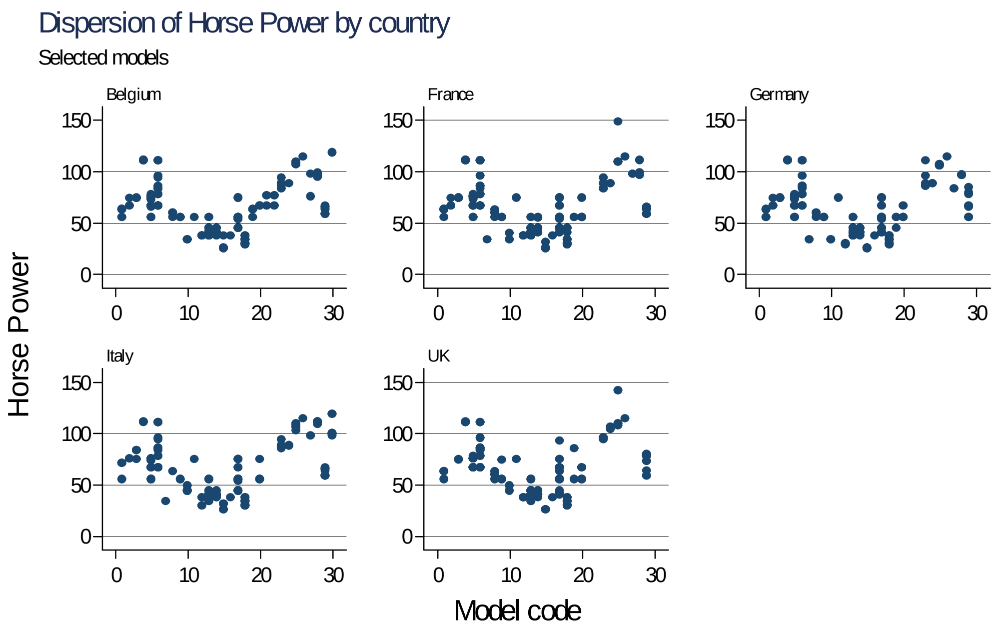


Figure 19:



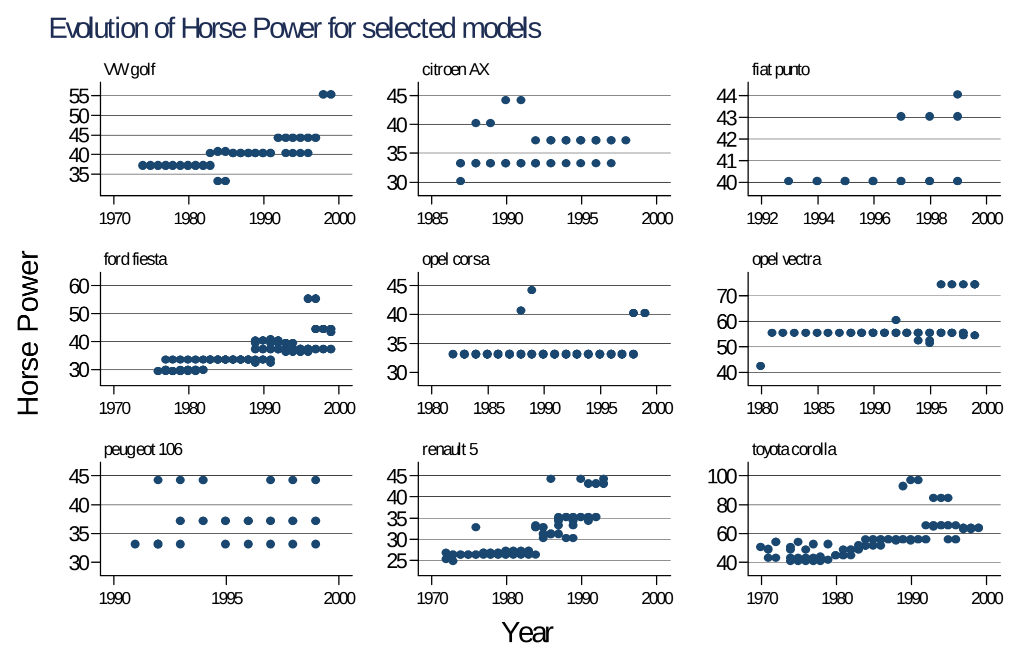
(Interpretation: Model code is on the horizontal axis. The vertical line passing through a given model code contains the years of exit of that model in each of the five markets. The dots for 1999 correspond to the end of the sample, and not to proper exits.)

Figure 20:



(Interpretation: For each country the model code is on the horizontal axis and horse power in the vertical axis. The vertical line crossing a given model code contains all the observations of horse power for that model in that country over time. If the vertical line contains only one dot it means that the characteristic did not vary at all for that model. Several dots over the vertical line mean that the characteristic has changed over time.)

Figure 21:



(Interpretation: For each model and for each year, the dots represent the observations of horse power in each of the five countries
A single dot for one year means that horse power was the same in all countries in that year. Two or more dots mean that the characteristic varied across some countries.)

Chapter 3

Entry and Profitability in Differentiated Product Markets: The Spanish Car Industry

3.1 Introduction

This chapter studies product entry decisions in the Spanish car market, the fifth-largest in Europe with annual sales of more than 20 billion euros. I understand by "entry" the introduction of a new model that then competes against the incumbent models for a stake of the market. This means I am not considering the entry of a firm itself; rather I want to model and describe when and why a new car model arrives on the market. Common sense indicates that firms are willing to introduce a new product when the expected revenue exceeds the fixed (or sunk) cost of development, which includes, for example, the R&D costs, plant setup or adaptation costs and advertisement costs.

I propose a two-stage, static model where first the decision of entry is made and then there is price competition. I assume single-product firms. These two assumptions make the analysis much simpler but they also have an impact on the results. A two-stage static model implies that for a product to enter in the first stage, the entry costs must be fully recovered in the price competition stage. In reality, this is not the case in the car industry, where product entry costs can be recovered during many periods. As a result, the model will imply entry rates smaller than the actual ones because entry is more difficult. In other words, this model cannot explain some part of the high real entry rates. The single-product assumption eliminates any strategic consideration of the firm regarding product proliferation, as for example entry deterrence behavior. We can expect more entry with respect to the multi-product firm case as the cannibalization effect is not taken into account. It is not clear whether these two effects compensate each other or one is stronger than the other, leaving the global effect undetermined.

The two-stage approach is common in the related literature and static approaches to the entry problem are not rare, as discussed below. The single-product assumption is an unusual one that I am making in this chapter for the sake of simplicity. The goal of the chapter is to get some insights into the phenomenon of entry using a simple model.

This chapter is inspired by and follows the literature on entry and competition in oligopolies. Many papers have addressed the issue of entry but most of them, especially in the early literature, focus on the number of firms the market can sustain and how many can enter/exit. For instance, Bresnahan and Reiss (1991b) propose a model that accounts for the number of entrants and a decision about entry based on having non-negative profits. However, the product is homogeneous and potential entrants are all identical. The focus of their paper is on competition and the evolution of market structure, so they do not consider firm specific analysis of the determinants of entry. Berry (1992) presents a two-stage model where firms first decide to stay or to leave and then they compete and earn profits. He provides conditions under which the equilibrium number of firms is unique but the identities of the entrants remain undetermined (this is similar to Bresnahan and Reiss (1991a), where a given market structure is compatible with several empirical observations). Profits drive the decision about entry. Variable profits are a function of market characteristics and market structure but do not explicitly depend on firms' strategies. Mazzeo (2002) is another two-stage differentiated product model where first entry and quality are decided and then firms compete. Profits are empirically characterized by a set of market demand characteristics and market structure. A general discussion of papers in this literature can be found in Toivanen and Waterson (2000).

More recently, we find other works that look at entry and / or competition in a more structural way, although still from a static perspective. Ishii (2005) presents a model for ATM networks in the banking industry where the bank first chooses the size of the network and then competes in prices (interest rates). In Seim (2006), firms first decide on entry and then they differentiate by choosing geographic locations.

Entry in the car market has been approached using reduced-form econometric models. Using UK data, Geroski and Murfin (1991) use a probit model to estimate the probability of entry as a function of post-entry advertising shares. They find evidence that usually entrants go first to the higher segments and then to the smaller ones. Moreover, prior experience in the market has a small effect on entry. Geroski and Mazzucato (2001) explain entry as a function of advertising in the US automobile market. Requena-Silvente and Walker (2005) study the relation between model survival and competition in the UK. They find evidence that intra-firm competition determines the exit of car models in small and large family cars, while in the Luxury/Sport segment, the relevant factor is inter-firm competition.

The Spanish market has been studied from the point of view of pricing behavior (Jaumandreu and Moral (2006)) and the role of advertising (Barroso (2007)).

In order to see the magnitude of the phenomenon of entry, I start by describing the industry from the point of view of entry-exit decisions. Section 3 describes the data base used. Section 4 presents a preliminary probit analysis describing correlations between entry and some relevant variables. The rules of firm and consumer behavior are presented in Section 5. The empirical implementation is in Section 6 and results are presented in Section 7. Finally, Section 8 concludes.

3.2 Entry (and Exit) in the Spanish Car Market During the 1990's

The period 1990-2000 shows an increasing trend in the number of models marketed (Table 2).

There are two main reasons behind this fact. Firstly, the Spanish market opened to foreign producers as a result of becoming a member of the European Community. Secondly, there is an increase in the number of models marketed by firms. I look at each one in more detail.

The entry of Spain into the European Community entailed a progressive reduction in the tariffs for imported cars in order to converge to the rates applied in the Union. This fostered the entry of many foreign producers, whose cars became cheaper. The evolution of tariffs is shown in Table 1. 1993 is the cut-off point. However, this does not appear to have a striking influence on the number of models marketed. Even if we consider that the introduction of a new model by a newcomer could be delayed until a commercial network is developed, i.e., effective entry may take some time after liberalization, this lag is not enough to explain the phenomenon of entry because the end date of commercial barriers was known and could have been anticipated. Table 1 shows that 1996 is somehow a breaking point after which the introduction of models speeds up, the main reason being the intensive entry by some (mainly Asian) newcomers. Figure 2 represents the proportion of the number of models marketed by domestic[1] firms (darker line), Europeans and others (thin line), including Asian and American producers. For example, the gap between lines 2 and 3 represents the presence (in terms of number of models marketed, and not in terms of market share) of Asian and American producers. This presence becomes

[1]Firms with production plants in Spain are considered domestic, no matter their country of origin or ownership. European producers are those producing in Europe but not in Spain. All remaining firms are classified as "Other" firms.

significantly greater circa 1996, and it focuses on the small-medium range of models.

The average (average by year and brand) proportion of entries per segment[2] in the sample period is between 2% and 8% . Those proportions are computed as follows: I generate an "enter" variable with 2904 observations (the combination of 8 segments, 11 years and 33 brands) that has a 1 if a brand in a particular year has introduced a model and a 0 otherwise. Then I compute by segment the proportion of ones. This procedure assumes that all the firms in our sample could have made a decision about entry at any moment of the sample. This is not realistic, because that was not possibly the case of most Asian producers. Moreover, following that argument, I could consider that any firm with or without a presence in the Spanish market could have entered, which would have forced us to include all manufacturers in the world. Therefore, a refinement on that procedure is to exclude a firm while it has not entered the Spanish market for the very first time. This affects only Subaru, Chrysler, Hyundai, Kia, Daewoo and Galloper, which entered the Spanish market for the first time after 1990. But it could also be the case that a firm leaves the market entirely and never comes back. In this scenario, it would not make much sense to include it as potential entrant in each period. This affects Yugo and Lada. The remaining firms are all present in every year in at least one segment. Therefore, if I forget about the firms that have not entered yet or which have left permanently, I get a file of 1075 decisions of "enter" "not enter". Computing the proportions of entry yields a pretty stable number of 15 % (Table 5). The average level of entry in the whole sample is roughly the same for all segments (it goes from 12.5% in the Luxury segment to 16.4% in the Compact segment. The 28.5% figure of the Minivan segment is due to the fact this is a really new segment and the process of entry is more intensive). By economic origin, domestic firms have a proportion of entries of

[2] I consider here the following 8-segment classification taken from industry sources: Small-Mini, Small, Compact, Intermediate, High Intermediate, Luxury, Sports, and Minivan.

10% for 20% of foreigners. Domestic firms, already present in most segments, just make a replacement effort and eventually enter new segments. By contrast, foreign firms (especially Asian) enter the Spanish market and also have to undertake model replacement.

Regarding the increase in the number of models marketed by firms, a glance at Figure 3 shows that almost all firms maintain or increase the number of models for sale in the sample period. Exceptions are short-lived brands and Rover. Tables 3 and 4 show how newcomers tend to occupy all "niches" and incumbents tend to reinforce their presence. Indeed, 6 out of 8 firms with no activity up to December 1989 were present in at least 3 segments by the end of 2000. Paradigmatic examples are Hyundai and Kia. Incumbents either maintain or increase the number of models for sale and the segments where they are present with an intensive activity of entry and exit of models. This can only correspond to replacement decisions in most cases (for example Renault, Ford, Peugeot).

In summary, apart from trade liberalization, there are at least two reasons behind the entry and exit decisions of each producer:

First, replacement decisions. A number of entry decisions, i.e., the introduction of a new model, is associated with a correspondent exit, in such a way that the firm just replaces one model with another, maybe with some degree of overlapping. The lifetime of a car model is limited and firms must keep on renewing their range of products in order to satisfy consumers' tastes[3].

Second, net entries. These are related to the "creation" of new segments or new

[3] Actually, in the early stages of the industry, the strategy of differentiation to meet local demand's tastes was the only way, along with trade barriers, for the European producers to compete with the cheaper, mass-produced American cars. Later, when free trade started to emerge within Europe and the national producers were able to take advantage of the economies of scale from serving a larger market, the strategy of differentiation was revealed as the critical determinant of the leadership of the European car industry in the subsequent decades. We could say that the 1960's was the period when product differentiation in the car industry was born. [See Altshuler, Anderson, Jones, Roos, and Womack (1984)]

bundles of characteristics significantly different from the existing ones. Examples of this are the introduction of the Minivan or the increasing popularity of the urban cars (Small-Mini segment). By contrast, some segments may become sort of "unpopular" and lose weight in the industry. This seems to be the case of the Intermediate segment, whose number of models declines as the Compact and High Intermediate segments go up.

3.3 Data Description

I use a unique data base of car model registrations in Spain over the period 1990-2000. These data were initially collected by, and first used in Moral (1999)[4], who also provides a thorough description of the data base. The unit of observation is a car model. A model is defined in the sample by its commercial name, as is common in the literature on the automobile industry (e.g., Brenkers and Verboven (2006)). The price and main characteristics of the car (such as power, speed, fuel consumption, dimension, ABS or air conditioning among others) are available in a monthly basis. Table 6 describes the characteristics used and their units of measure. The sample is filtered to exclude super luxury models (e.g., Ferrari, Rolls Royce) and cars with fewer than 10 registrations per month. Nevertheless, the sample represents more than 99% of total registrations during the sample period. Car producers usually offer a number of variants of each model. For each model, the most popular variant is chosen as representative of model characteristics. Therefore, the observed variation in characteristics will correspond to changes in characteristics of the representative variant. All registrations from the other variants are attributed to the representative one. Models are grouped according to an 8-segment classification: Small-Mini, Small, Compact, Intermediate, High Intermediate, Luxury, Sport, and

[4] The data base here, which runs from January 1990 to December 1996, has later been extended up to December 2000.

Minivan. Table 7 shows as an illustration some examples of car models included in each group. The classification is taken from industry sources[5].

3.4 Descriptive Probit Analysis

The depiction of the empirical framework can be completed by looking at the correlations among variables that arise in a probit model. I explain the probability of entry with some basic variables that attempt to capture firm characteristics (but not rivals' characteristics) and some market characteristics. In particular, I use: the average real price of cars, as a proxy or index for the bundle of characteristics, the total number of models of each firm (proxy for variety), the age of the oldest model for each firm (proxy for the incentive to replace old models), the proportion of entries over the total number of models in each period, and the ratio of segment sales over total sales (proxy for the importance of entry in some segments). I also include dummy variables to control for year, segment, economic origin of the firm (domestic, European or other), and tariffs. These controls intend to capture some market characteristics such as the intensity of foreign competition or the economic cycle. Using prices as a proxy for characteristics could entail some endogeneity problems. This may also be the case of variables based on sales or proportion of entries. Being aware of this issue, I maintain those regressors because I am using this probit just as a simple preliminary way to study correlations among entry and firm and market characteristics. Hence, the insights from this section are conditioned by that caveat.

I consider the non-augmented sample (1075 observations), partially-augmented sample (2584 observations) and the augmented sample (2904 observations), defined as in the previous section Table 8 reports a brief summary of results.

The best results are given by the parsimonious specifications of Table 8 with

[5]See, for example, the industry report for Spain, ANFAC (2006).

no dummies for year or segment for any of the alternative samples. In these, all coefficients are highly significant and moreover robust to several probit specifications.

The remarkable findings are the positive sign for the coefficient of the number of models and negative sign for the age of the oldest model. This can be interpreted as the existence of a strong correlation or "clustering" in the decisions of entry. The negative sign of "maxage" means that the probability of entering increases as the contemporaneous mean average of the models marketed decreases. This average is computed each period taking into account the age of the "new" models; hence, if for some reason many models are introduced at the same time, the average will be smaller and at the same time entry is high. If firms do not coordinate or enter at the same time, spreading entries over time, we should not observe a deep fall in mean age nor a significant amount of entries, thus having a pair of uncorrelated variables. This is not the case, as the coefficient appears to be highly significant in all regressions run. This correlation is not surprising if we look at Table 2, where entries take place intensively in certain years. The positive sign of "number" indicates that the more models there are on the market, the more likely entry is, thus feeding back the stock of models sold. This reflects the fact that entry rates speed up in the sample period. Notice that there could have been an increase in the total number of models as a consequence of smaller exit rates and stable entry rates. The positive coefficient tells us that, no matter what happens with exit, entry is fostered as variety increases.

The other variables have the expected signs: higher real prices are positively correlated with entry, European and Asian-American firms enter more intensely and the higher the importance of a segment, the more likely entry is. The "tariffs" variable should have a negative impact but it is non-significant most of the time (although when it approaches significance its sign is indeed negative).

3.5 Agent Behavior

3.5.1 Consumer Behavior

In this part, I follow the well established literature on random utility models (Anderson, de Palma, and Thisse (1992)). As I consider the case of single-product firms competing in prices, the baseline demand model is the standard multinomial logit with price competition. Consumers demand either one unit of the good or none. They derive utility from the characteristics of the product. The utility from consuming product i is given by: $U_i = k_i - \alpha p_i + \omega_i + \epsilon_i = u_i + \epsilon_i$ where p_i denotes the price, α stands for the marginal utility of income, k_i is a quality index summarizing the observable characteristics of the good, and ω_i is an unobservable product characteristic. ϵ_i is an idiosyncratic error term; the $\epsilon_i' s$ are assumed to be *iid* with a type I extreme value distribution. μ is a parameter proportional to the variance of the $\epsilon_i' s$, measuring the degree of product heterogeneity. Denoting by M the market size, total demand is $D_i = S_i M$, with market share, S_i, given by:

$$S_i = \frac{\exp\left(\frac{u_i}{\mu}\right)}{1 + \sum_{j=1}^{N} \exp\left(\frac{u_j}{\mu}\right)}$$

3.5.2 Firm Behavior

Firms are profit maximizers that compete by playing the following stage game: they first decide whether to enter with some given characteristics, summarized by the index k, which has an associated cost given by $F(k_i)$. Then they compete in prices, having observed the results of the first stage. Therefore, the model accounts for the relation of entry with price competition. $F(k_i)$ is not a production cost, it is the cost associated with entering with quality k_i (it might include a number of elements such as the R&D cost , advertising cost, or design or plant modification needed). The product can be replicated at a constant marginal cost of production $C(D_i) = c_i D_i$.

Profits from product i , if it has entered, are defined by:

$$\pi_i = (p_i - c_i) S_i M - F(k_i) \tag{1}$$

and zero if the product is not on the market (its market share is zero):

$$\pi_i = \begin{cases} (p_i - c_i) S_i M - F(k_i) & , if\ entry \\ 0 & , if\ no\ entry \end{cases}$$

Maximizing (1) with respect to price we obtain:

$$MS_i + M(p_i - c_i) \frac{-\alpha}{\mu} S_i (1 - S_i) = 0$$

such that if entry happens in the first stage, variable profits are:

$$\pi_i^v = \frac{\mu}{\alpha} \frac{S_i}{1 - S_i}$$

3.6 Empirical Model and Estimation

In the first stage of the game, entry takes place if it is more profitable than staying out. As in Geroski and Murfin (1991), I formulate a probit of entry, although in my case it is based on the equation of profits. Let's denote by ξ an iid normal random shock, $\xi_i \sim N(0, 1)$. Then:

$$\begin{aligned} \Pr(entry) &= \Pr(\pi_i > 0) = \Pr(E(\pi_i^v) - F(k_i) + \xi_i > 0) = \\ &= \Pr(\xi_i > -(E(\pi_i^v) - F(k_i))) = F_\xi(E(\pi_i^v) - F(k_i)) \end{aligned}$$

where expected variable profits can be defined as: $E\left(\pi_i^v\right) = \frac{\mu}{\alpha}\frac{E(S_i)}{1-E(S_i)}M$. The market size, M, is approximated by the number of households per year. α is obtained from demand estimation.

I pool the data to fit the probit model. This is equivalent to assuming that firms' behavior is independent from one wave to another.

Characteristics influence the demand for a model, so it seems reasonable to include them as determinants of the decision of entry: whether to enter or not is as relevant as where to enter. Therefore, entry, choice of characteristics and (price) competition are closely linked. However, in this model, I abstract from the choice of characteristics (the choice of segment) and I concentrate on the relation between entry and competition. This simplification is also consistent with assuming firms taking independent decisions across segments: Ford in the Small segment behaves as if it were a different firm from Ford in the Intermediate segment.

The issue of expected market shares deserves some discussion. We observe the characteristics and sales of the products that successfully enter, so I can assume perfect foresight and consider that the market share expected a priori is the same as that which is realized a posteriori. What about the "failed entries"? i.e., how can we approximate the expected market share of a model which has not entered? Here we have two possibilities. First, the segment-firm has never been present in the Spanish market. In this case, I do not consider it a potential entrant until it enters for the very first time. This is equivalent to assuming that the first entry of any firm is always successful and that if I have not observed it in a particular market, it is because the firm does not want to do it, whatever the reason (dimension, international presence policy, etc.). If I do not make this assumption, I would have to regard as a potential entrant any car producer of the world. Second, the segment-firm has entered before. In this case, there are at least two alternative approximations of the market share:

- Approach 1: if the firm already has a product for sale and I can assume that, had it been able to introduce another product, it would enjoy the same market share, i.e., the failed entrant is at most (and in the limit equal) as good as the incumbent product. Therefore, there are observations for each product in several years; some of these correspond to entry periods while others do not. What I am assuming is that in the periods where there is no entry but the segment-firm is still present, the characteristics and expected share of the failed product are equivalent to those of the product already present. The segment-firm would enter only with a product "better" than the one it is currently offering.

- Approach 2: I estimate the parameters of demand and use these estimates to simulate the expected market shares an entrant would have. Using the data on characteristics and prices, I can compute the associated market share[6]. This can be regarded as the share firms expect to get by introducing a model with those particular characteristics. The assumption here is that failed entrants would have entered with the same characteristics as the "old" models, i.e., the failed entrant is at most as good as an existing model. Details on demand estimation are given below.

I only have to estimate the ratio $\frac{\mu}{\alpha}$ which is likely to vary across segments, so I interact $\frac{S_i}{1-S_i}M$ with segment dummies to control for that.

I adopt a simple form for the fixed cost function that makes it vary with segment instead of varying with k_i. Therefore, I will be estimating a fixed cost of entry by segment. I also introduce a set of dummies to control for origin (either domestic, European or non-European firm) and a count of the models each segment-firm has

[6]What I have done is the following: from my original sample, I have obtained a simplified data set with one observation per segment, year, and brand. For each observation, I observe the average of the relevant characteristics and prices. Using this information and the estimation of demand parameters, I compute the market share. This is the simulated market share used later in the estimation of the structural equation.

per period (to control for synergies between models at the time of entry).

3.6.1 Demand Estimation

I estimate the market share of each product. Normalizing by the outside good and taking logs produces the standard equation:

$$\ln S_i - \ln S_0 = k_i - \alpha p_i = \sum_c a_c \beta_c - \alpha p_i$$

The quality index, k_i, is obtained as the weighted sum of characteristics, denoted by a_c, using as weights their correspondent parameters from demand estimation, the β_c's. From the basic model, a sensible econometric specification is:

$$\ln S_i - \ln S_0 = \sum_c a_{c,i} \beta_c - \alpha_s p_i + \zeta_s + \upsilon_f + \eta_i + \epsilon_i \tag{2}$$

where α_s is a segment-specific marginal utility of income obtained by interacting with segment dummies. As segmentation has a vertical component, we can expect that consumers buying from higher segments have lower α than those buying from lower ones. ζ_s, υ_f, η_i are, respectively, segment, firm and product unobservables (observed by consumers but unobserved to the econometrician). ϵ_i is the idiosyncratic error.

3.6.2 Empirical Specification of the Demand Equation

The market share of the outside good is computed as a residual from the total amount of sales.

A reduced amount of characteristics has been chosen in order to conform to the existing literature (see, for example, Berry, Levinsohn, and Pakes (1995) or Jaumandreu and Moral (2006)). In particular, I consider the cubic centimeters/weight ratio, the car size (length times width), the kilometers run with one litre of fuel, maximum speed, air conditioning, and ABS. I introduce a set of dummies to control for firm and segment unobservables and the age of the model (in levels and squared). I estimate equation (2) using two- stage least squares. Endogeneity of prices is controlled for by instrumenting them with a 12-month lagged deviation with respect to their individual time mean[7], as suggested in Arellano and Bover (1995), and the unobserved product component is considered to be a random effect, i.e., it is assumed to be uncorrelated with the remaining explanatory variables.

Table 9 presents estimation results. An increase in any characteristic means a better car, so the positive sign obtained in the estimation is what is expected. Price coefficients are negative for all segments but the Small one, the reason for this unclear. In any case, it is clear that the marginal utility of income is different among segments. In particular, for the segments that can be ordered "vertically" in quality (Small-Mini, Small, Compact, Intermediate, High Intermediate, Luxury), we observe a higher marginal utility of income for the lower ones.

These estimates are then used to simulate the market share that would correspond to some set of given characteristics, as described above.

3.7 Results

The estimation of structural probit following approach 1 yields the right sign for all the dummies of segment, which are expected to be negative (the greater the cost of entry, the less entry we see). Regarding the segment-specific demand parameters, positive signs should be expected: the more profitable a model is, the more likely entry is. However, I get positive signs only in the Small-Mini, Intermediate and Sport segments, in the alternative specifications tried, even after controlling for origin

[7]For instance, p_{it} is instrumented by $\tilde{p}_{it}$ lagged 12 months, where $\tilde{p}_{it} = p_{it} - \frac{1}{T_i}\sum_{t=1}^{T_i} p_{it}$, and T_i is the number of time observations of good i.

or other characteristics. The negative signs in the remaining demand parameters contradict what is expected from the model and it is indicative of the poorness of the first approach[8]. The assumption made assigns too low a market share to entrants and too high a share to non-entries because I am approximating failed entries with the market share of car models which sell well. Though they have not entered in the current period, they may have entered "recently", meaning one or two periods earlier, and so are attractive enough to gain a good stake of the market.

Results from approach 2 are summarized in Table 10. I present specifications with different combinations of controls. Among them, the preferred specification is in Column 4 ("probit 3") as it is a parsimonious representation of the structural models. All coefficients have the expected sign and are robust to alternative specifications. The probability of entry increases in variable profits and it is decreasing in fixed cost. The demand parameters show which segments are more worth fighting for in terms of variable profits: $\frac{\partial}{\partial S}(p-c) = \frac{\partial}{\partial S}\left(\frac{\mu}{\alpha} * \frac{1}{1-S}\right) = \frac{\mu}{\alpha}\frac{1}{(1-S)^2} > 0$ and $\frac{\partial}{\partial S}\left(\frac{1}{(1-S)^2}\right) = \frac{2}{(1-S)^3} > 1$. This means that the gross mark-up is increasing and convex in market share, which makes sense because price elasticity is decreasing in market share[9] (this is a consequence of the logit assumption). Moreover, the gross markup is decreasing in the marginal utility of income (price elasticity increases in α). The higher the μ is, the higher the increase in profits is when the market share goes up. The increase is even higher when the market share is higher. μ is a measure of the degree of heterogeneity or dispersion (the variance of ϵ is proportional to μ) .This means that the less substitutable the products are, the higher the markup can be. The most interesting segments are those which simultaneously have a high market share and high $\frac{\mu}{\alpha}$. This happens with some of the Intermediate and the Small segments. The

[8] That is why I omit the presentation of results.

[9] Price elasticity is: $\varepsilon = \frac{\partial S}{\partial p}\frac{p}{S} = \frac{1}{\mu}\alpha S(1-S)\frac{p}{S} = \frac{1}{\mu}\alpha(1-S)p$. Then: $\frac{\partial}{\partial S}[\frac{1}{\mu}\alpha(1-S)p] = \frac{1}{\mu}\alpha p(-1) < 0$.

high coefficient of minivans and sports cars is misleading because of the small market share they represent (particularly the sports cars). For a given market share, the smallest probability of entry would correspond to the Small and Compact segments. However, the fact that these are the most popular segments (with more than 30% of the total market each, see table 11) puts them among the most profitable.

I use the estimated model ("probit 3") to simulate the average realized profits of operating in the Spanish market per year and segment (Figure 5). These do not pretend to be accurate estimations of real profits; the only important thing here is the ordering of segments in terms of profitability. The High Intermediate segment seems to be more profitable over time (always first or second in the ranking of profitability). It is also second in the ranking of the number of entries. The Small and Compact segments also present a stable pattern of profitability. They record high levels of entry although they are slightly above average in profitability. Minivans steadily increase their popularity (share) and profitability. The Intermediate segment suffers dramatic changes in popularity and profitability: initially, it is fairly popular and registers a good number of entries. After 1993, it becomes unpopular and there are almost no new models added, which corresponds to the low levels of profitability shown. But at the end of the sample, it recovers some strength and becomes by far the most profitable segment.

In summary, it is possible to distinguish two types of segments: those which are stable and which most firms wish to be present in (Small, Compact, High Intermediate) and other segments with an irregular performance and more subject to short-run trends or fashion aspects (Small-Mini, Intermediate). The popularity of these segments may be linked to firms' product differentiation and proliferation strategies. However, the single-product assumption rules out the consideration of this possibility in this model, because firms are forced to ignore the effects of a new entry on their own products. As a result, there may be a biased incentive for entry with respect to the case of multi-product firms.

The better opportunities for entry are in segments with good profitability, but the stability of profits is also important. That is why most of the entrants go to segments of the first type. The most representative fact supporting this conclusion is that the segment with the highest number of entries is the Compact (which represents 32% of the market, second right after the Small segment) (see Table 12 and Table 11), although it is fifth in the ranking of estimated profits (Figure 5). Nevertheless, the static nature of the model, which forces the recovery of entry costs in the next period, may be biasing the results. Part of the gap between observed entry rates and estimated profitability may be due to the fact that a static model would require small fixed costs many times in order to accommodate real entry rates. The probability of having those small fixed costs would be very small. In practice, the static model would only be consistent with lower rates of entry and lower profitability even if in reality we observe higher entry rates. However, this bias would be affecting all segments such that relative positions should not be affected much. As such, the result can still provide some insights into decisions of entry: firms prefer to introduce their products where it is safer to recover costs. They would prefer segments where there is some certainty about future profits, rather than segments where profits vary greatly.

3.8 Conclusion

This chapter studies the determinants of product entry decisions in the Spanish car market. There are several reasons behind the decision to introduce new products, such as replacement of old goods, proliferation, or strategic reaction to competitors' actions. It is common to observe firms regularly introducing new products. Sometimes entries take place in a massive way and on other occasions they are rather sparse. Here we propose a two-stage, static model of entry and price competition among single-product firms. The rationale for entry is that expected profits are higher than fixed costs. The model is estimated using data on entries and characteristics for the Spanish car industry in the period 1990-2000. As the products which do not enter are not observed in the sample, it is necessary to simulate their market share before running the estimation. By doing so, the positive relation between entry and variable profits and the negative relation with fixed cost of entry are confirmed. Moreover, the chapter shows how the phenomenon of entry is associated with the perspectives of profitability in each segment. In the model, segments with the higher rates of entry need not always be the most profitable. Profits are the main driving force of entry but the existence of a stable demand or market share for the model is also a key factor.

These results have to be considered with caution. The static nature of the model may introduce a bias in the relation between entry and profitability. Moreover, the single-product assumption excludes any consideration of product proliferation strategies, which is a relevant factor to explain entry decisions. For this reason, the next chapter will focus on building up a dynamic oligopoly model of competition among multiproduct firms, taking into explicit consideration the possibility of the existence of product proliferation incentives from the firms' cost side. The aim will be to overcome these caveats and provide further insights into the determinants of product introduction decisions.

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Graphics and Tables

Table 1: Tariffs on imported cars

Spain	Tariffs on cars from:	1990	1991	1992	1993 onwards
	EU	12.4	8.3	4.1	0
	Non-EU	23.6	18.7	13.8	10.3

EU	Tariffs on cars from:	1990	1991	1992	1993 onwards
	EU	0	0	0	0
	Non-EU	10.3	10.3	10.3	10.3

Table 2: Gross number of entries and exits by year

YEAR	STOCK	GROSS ENTRIES	GROSS EXITS
1990	77	20	2
1991	95	10	5
1992	100	16	10
1993	106	11	8
1994	109	13	12
1995	110	17	11
1996	116	18	13
1997	121	29	10
1998	140	19	10
1999	149	11	7
2000	153	16	10
2001	159	-	-

Table 3: Entries and exits by firm

Brand	Initial number of models	Entries in jan-1990	Initial number of segments	Initial segments	Final number of models	Final number of segments	Final segments	Total number of entries	Total number of exits	Net balance of entries-exits
Alfa Romeo	3	-	3	(3,4,6)	4	3	(3,5,6)	5	4	1
Audi	3	-	3	(4,5,7)	6	5	(2,3,5,6,7)	7	4	3
BMW	7	1 (BMW 535)	2	(5,6)	10	3	(5,6,7)	5	2	3
Chrysler	0	-	0	-	6	4	(3,5,6,8)	7	1	6
Citroen	3	-	3	(2,4,6)	4	4	(2,4,5,8)	5	4	1
Daewoo	0	-	0	-	6	5	(2,3,4,5,8)	8	2	6
Fiat	4	1 (Panda)	3	(2,3,4)	8	6	(1,2,3,4,7,8)	12	8	4
Ford	5	-	5	(2,3,4,5,6)	8	6	(1,2,3,5,7,8)	8	5	3
Galloper	0	-	0	-	1	1	(8)	1	0	1
Honda	1	-	1	(5)	4	3	(2,3,5)	4	1	3
Hyundai	0	-	0	-	7	6	(2,3,5,6,7,8)	9	2	7
Jaguar	1	-	1	(7)	1	1	(7)	0	0	0
Kia	0	-	0	-	7	3	(3,5,8)	8	1	7
Lada	1	-	1	(2)	0	0	-	0	1	-1
Lancia	3	1 (Dedra)	3	(1,3,4)	3	3	(2,5,6)	4	4	0
Mazda	2	-	2	(3,5)	5	5	(2,3,5,7,8)	4	1	3
Mercedes Benz	4	1 (S-300)	2	(5,6)	12	4	(5,6,7,8)	9	1	8
Mitsubishi	0	1 (Galant)	0	-	3	3	(3,4,8)	3	0	3
Nissan	2	-	2	(3,4)	6	5	(2,3,5,6,8)	8	4	4
Opel	5	-	4	(2,3,5,6)	7	6	(2,3,5,6,7,8)	7	5	2
Peugeot	5	-	5	(2,3,4,5,6)	6	5	(2,3,5,6,8)	6	5	1
Porsche	1	-	1	(7)	1	1	(7)	0	0	0
Renault	6	-	5	(2,3,5,6,8)	6	6	(1,2,3,5,6,8)	5	5	0
Rover	4	-	4	(1,3,4,6)	3	3	(3,4,5)	13	14	-1
Saab	2	-	2	(5,6)	2	2	(5,6)	2	2	0
Seat	3	-	3	(1,2,3)	6	5	(1,2,3,4,8)	5	2	3
Skoda	1	-	1	(2)	3	3	(2,3,4)	5	3	2
Subaru	0	-	0	-	1	1	(6)	1	0	1
Suzuki	0	1 (Swift)	0	-	3	3	(2,3,8)	5	2	3
Toyota	3	1 (Corolla)	2	(6,7)	6	4	(2,5,7,8)	7	4	3
Volkswagen	6	-	5	(2,3,4,5,7)	7	6	(1,2,3,4,5,8)	5	4	1
Volvo	1	2 (Volvo 440, Volvo 740)	1	(3)	7	3	(5,6,7)	12	6	6
Yugo	1	-	1	(2)	0	0	-	0	1	-1
TOTALS	77	9			159			180	98	82

Segment codes: Small-Mini (1), Small (2), Compact (3), Intermediate (4), High Intermediate (5), Luxury (6), Sport (7), Minivan (8)

Table 4: Entry and exit activity of newcomers

Brand	Date of entry	Number of models introduced in their first natural year	Number of segments covered	Segments covered	Final number of models	Final number of segments	Final segments	Total number of entries	Total number of exits	Net balance of entries-exits	Total number of models marketed
Chrysler	1992, Feb	2	2	(7,8)	6	4	(3,5,6,8)	7	1	6	7
Daewoo	1995, Mar	2	2	(3,4)	6	5	(2,3,4,5,8)	8	2	6	8
Galloper	1998, Nov	1	1	(8)	1	1	(8)	1	0	1	1
Hyundai	1992, Jan	4	4	(5,6,7,8)	7	6	(2,3,5,6,7,8)	9	2	7	9
Kia	1997, Jan	3	3	(2,3,5)	7	3	(3,5,8)	8	1	7	8
Mitsubishi	1990, Jan	1	1	(4)	3	3	(3,4,8)	3	0	3	3
Subaru	1991, Jan	1	1	(6)	1	1	(6)	1	0	1	1
Suzuki	1990, Jan	1	1	(2)	3	3	(2,3,8)	5	2	3	5

Segment codes: Small-Mini (1), Small (2), Compact (3), Intermediate (4), High Intermediate (5), Luxury (6), Sport (7), Minivan (8)

Table 5: Percentages of entry by segment and nature of firms

	SEGMENT								
ECONOMIC ORIGIN	**Small-Mini**	**Small**	**Compact**	**Intermediate**	**High Intermediate**	**Luxury**	**Sport**	**Minivan**	**Total**
Domestic (%)	**0,148**	**0,065**	**0,108**	**0,179**	**0,063**	**0,038**	**0,182**	**0,163**	**0,103**
(# obs)	27	77	74	39	63	52	22	43	397
European (%)	**0,167**	**0,186**	**0,192**	**0,149**	**0,165**	**0,175**	**0,12**	**0,364**	**0,171**
(# obs)	18	43	52	47	79	80	50	11	380
Non-European (%)	-	**0,243**	**0,203**	**0,158**	**0,19**	**0,139**	**0,167**	**0,405**	**0,215**
(# obs)	-	37	69	19	58	36	42	37	298
Total	**0,156**	**0,14**	**0,164**	**0,162**	**0,14**	**0,125**	**0,149**	**0,286**	**0,158**
(# obs)	45	157	195	105	200	168	114	91	1,075

Table 6: Definition of characteristics and units of measure

Characteristic	Unit of measure
Cubic Centimeters	Itself
Weight	Kilograms
Cubic Centimeters per Kg.	cc/kg
Length	Centimeters
Width	Centimeters
Car Size	Length * Width measured in square meters
Maximum Speed	Km/hour
Fuel Consumption	Litres/100 Km.
Price	1000's €
Real Price	Computed using the spanish consumption price index IPC
Air Conditioning	Dummy =1 if the car has the characteristic
ABS	Dummy =1 if the car has the characteristic
Registrations	In units
Market Size	Number of households, in 1000's

Table 7: Some examples of models included in different segments

Segment	Example
Small-Mini	Ford Ka, Fiat Cinquecento, Renault Twingo, Seat Arousa
Small	Citroen AX, Lada Samara, Opel Corsa, Peugeot 205, Yugo, Fiat Uno, Ford Fiesta, Seat Ibiza, Volkswagen Polo, Nissan Micra, Rover 114, Skoda Felicia, Daewoo Matiz, Hyundai Atos, Kia Pride
Compact	Audi A3, Rover 146, Rover 218, Citroen ZX, Fiat Bravo, Daewoo Lanos, Ford Focus, Honda Civic, Hyundai Accent, Opel Astra, Lancia Delta, Renault Megane, Seat Cordoba, Volkswagen Golf, Kia Rio
Intermediate	Citroen BX, Daewoo Nubira, Ford Orion, Rover Montego, Rover 418, Seat Toledo, Seat Leon, Volkswagen Bora, Volvo 440
High Intermediate	Audi A4, Citroen Xantia, Chrysler Neon, Daewoo Leganza, Ford Mondeo, Honda Accord, Hyundai Lantra, Mercedes C180, Nissan Primera, Opel Vectra, Peugeot 406, Renault Laguna, Toyota Corolla, Volkswagen Passat, Volvo S60, Kia Clarus
Luxury	Audi A6, BMW 535, Chrysler Stratus, Hyundai Sonata, Mercedes E400, Opel Omega, Renault Safrane, Saab 9000, Volvo S80
Sport	Audi TT, BMW Z3, Ford Cougar, Hyundai Coupe, Jaguar XJ, Mercedes SLK, Porsche 911, Opel Calibra, Toyota Celica,
Minivan	Citroen Evasion, Chrysler Voyager, Daewoo Tacuma, Fiat Multipla, Ford Galaxy, Mercedes A140, Nissan Serena, Peugeot 806, Renault Space, Seat Alhambra, Volkswagen Sharan, Kia Carens

Table 8: Summary of selected descriptive probit specifications

Dependent variable:	**Specification 1**	**Specification 2**
Enter	**Marginal Effects (Standard error)**	**Marginal Effects (Standard error)**
Average Real Price (Thousand €)	0,003525* (0,001284)	0,0035398* (0,0012943)
Number of models	0,0719273* (0,0135305)	0,0722675* (0,0137404)
Age of brand's oldest model	-0,001453* (0,0002173)	-0,0014543* (0,0002182)
Ratio of entries to stock of models	0,956466* (0,1060087)	0,9504794* (0,1069682)
Segment share	0,2448921* (0,0677175)	0,2442937* (0,0680388)
European brand	0,0251597 (0,0169188)	0,0258207 (0,0164597)
Non-European brand	0,0419659*** (0,0235581)	0,0335443 (0,0299674)
Tariffs	-	0,0009161 (0,0016577)
obs. P	0,1581395	0,1581395
pred. P	0,1135579	0,1134792
# obs.	1075	1075
wald Chi-2	191,63	195,41
(Df)	(7)	(8)
Prob>Chi-2	0	0

*, **, *** means significance at
1%, 5%, and 10% respectively

Table 9: Demand Estimation (Random Effects)

Dependent Variable: Market share	**Coefficient**	**Standard Error**
Characteristics:		
Cubic Cent./Kg.	0,3261633 *	0,0878
Car Size (Length x Width)	0,2827675 *	0,0437
Km. With 1 L. Of fuel	0,0425874 *	0,0081
Maximum Speed	0,0010	0,0020
Age in years	-0,1931445 *	0,0196
Age squared	0,0040193 *	0,0003
Air Conditioning	0,095326 *	0,0361
ABS	0,3625136 *	0,0319
Real price coefficients:		
Small-Mini	-0,3630397 **	0,1539
Small	0,3165384 *	0,0634
Compact	-0,1432025 **	0,0615
Intermediate	-0,0989246 ***	0,0547
High Intermediate	-0,1810073 *	0,0280
Luxury	-0,0215	0,0147
Sport	-0,1881806 *	0,0415
Minivan	-0,107112 **	0,0514
Constant	-12,49829 *	1,3802
Segment Dummies	Yes	
Year Dummies	Yes	
Brand Dummies	Yes	
# Obs	12488	
sigma eta (St. Dev. of the unobserved component)	2,1820	
sigma e (St. Dev. of the error term)	0,7350	
rho (Fraction of variance due to eta)	0,8981	

*, **, *** mean significance at 1%,5%, and 10%, respectively

Table 10: Selected structural probit estimations

Structural Probits:	Probit 1	Probit 2	Probit 3	Probit 4	Probit 5
Dependent Variable: Probability of entry	Coefficient (Standard Error)	Coefficient (Standard Error)	Coefficient (Standard Error)	Coefficient (Standard Error)	Coefficient (Standard Error)
Price coefficients:					
Small-Mini	1,7917	1,5577	2,2224	1,8495	2,0581
	(0,8748)	(0,8915)	(0,8974)	(0,8773)	(0,9193)
Small	0,5492	0,4228	0,6711	0,5550	0,5580
	(0,1563)	(0,1624)	(0,1609)	(0,1566)	(0,1678)
Compact	0,4116	0,4439	0,4965	0,4034	0,5393
	(0,1463)	(0,1495)	(0,1488)	(0,1465)	(0,1528)
Intermediate	1,5418	1,5015	1,8272	1,5483	1,8300
	(0,3790)	(0,3813)	(0,3913)	(0,3814)	(0,3971)
High Intermediate	1,3782	1,6037	1,7765	1,3390	2,0551
	(0,7686)	(0,7824)	(0,7907)	(0,7665)	(0,8090)
Luxury	2,0186	1,9802	2,2432	1,9364	2,1791
	(0,7142)	(0,7735)	(0,7331)	(0,7165)	(0,7985)
Sport	2,7105	2,3557	3,0120	2,6710	2,6181
	(0,8442)	(0,8570)	(0,8683)	(0,8466)	(0,8900)
Minivan	4,3890	4,4483	4,8958	4,3716	4,9553
	(2,0361)	(2,0480)	(2,0967)	(2,0402)	(2,1174)
Fixed Costs:					
Small-Mini	-0,5066	-0,2922	-0,6919	-0,5549	-0,5270
	(0,5116)	(0,5216)	(0,5235)	(0,5144)	(0,5352)
Small	-0,4776	-0,3516	-0,5799	-0,5100	-0,4926
	(0,3246)	(0,3292)	(0,3344)	(0,3262)	(0,3403)
Compact	-0,2859	-0,3347	-0,3719	-0,3062	-0,4631
	(0,3018)	(0,3064)	(0,3081)	(0,3025)	(0,3134)
Intermediate	-0,5850	-0,5039	-0,7307	-0,6248	-0,7046
	(0,3446)	(0,3494)	(0,3547)	(0,3469)	(0,3607)
High Intermediate	-0,3966	-0,4330	-0,5154	-0,4161	-0,6042
	(0,3131)	(0,3167)	(0,3212)	(0,3137)	(0,3264)
Luxury	-0,6894	-0,8474	-0,8037	-0,7023	-1,0101
	(0,3378)	(0,3541)	(0,3464)	(0,3381)	(0,3652)
Sport	-0,5675	-0,3880	-0,6442	-0,5832	-0,4841
	(0,3284)	(0,3323)	(0,3356)	(0,3289)	(0,3401)
Constant (Minivan)	-1,6452	-2,1484	-1,1629	-1,6494	-1,5888
	(0,3041)	(0,3201)	(0,3491)	(0,3043)	(0,3607)
Controls:					
European	0,9479	0,7015	1,0434	0,9417	0,7867
	(0,1615)	(0,1720)	(0,1665)	(0,1615)	(0,1774)
Non-European	1,0264	1,0365	1,1527	1,0284	1,1904
	(0,1608)	(0,1652)	(0,1665)	(0,1609)	(0,1724)
Number of Models	-	0,3973	-	-	0,4406
		(0,0642)			(0,0669)
Dummy for the Existence of Tariffs	-	-	-	0,1328	-
				(0,1169)	
Dummies for Year	No	No	Yes	No	Yes
# Obs.	1075	1075	1075	1075	1075
L.R. Statistic	80,41	118,74	113,81	81,69	157,61
(D.f.)	(17)	(18)	(27)	(18)	(28)
Pseudo R2	0,0857	0,1265	0,1213	0,087	0,1679

Note: price coefficients are estimates of the ratio $\frac{\mu}{\alpha}$.

Table 11: Market shares by segment and year

Market share (%)	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**Mean**
Small-Mini	2,33	1,93	1,55	2,80	4,87	4,20	3,14	3,69	3,20	2,43	1,42	2,87
Small	39,52	38,06	34,38	33,70	34,86	36,40	34,93	32,86	29,24	29,03	28,72	33,79
Compact	30,76	29,75	31,50	31,12	33,08	32,53	34,50	33,62	32,11	33,25	32,69	32,27
Intermediate	9,29	11,00	12,57	9,74	6,06	4,79	4,40	4,48	9,14	10,42	12,89	8,62
High Intermediate	13,51	13,82	14,29	17,05	16,40	16,60	17,82	18,87	19,21	17,85	16,40	16,53
Luxury	3,72	4,08	4,05	3,87	3,14	3,34	3,20	3,11	2,88	2,78	2,88	3,37
Sport	0,78	1,23	1,29	1,05	0,89	1,17	0,85	1,57	1,61	1,65	1,51	1,24
MiniVan	0,10	0,13	0,37	0,68	0,71	0,97	1,16	1,80	2,60	2,60	3,49	1,33

Table 12: Entries by segment and year

Entries per year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**Total**
Small-Mini	1	.	1	1	.	.	1	1	2	.	.	7
Small	3	1	2	1	1	1	3	1	5	2	2	22
Compact	3	3	1	2	2	5	5	3	2	3	3	32
Intermediate	2	3	1	2	.	1	2	3	.	2	1	17
High Intermediate	5	.	2	4	3	2	1	7	1	2	1	28
Luxury	4	1	3	.	2	3	.	4	3	.	1	21
Sport	1	1	3	.	2	2	2	2	3	.	1	17
MiniVan	.	.	2	.	2	2	3	6	3	2	6	26
Total	19	9	15	10	12	16	17	27	19	11	15	170

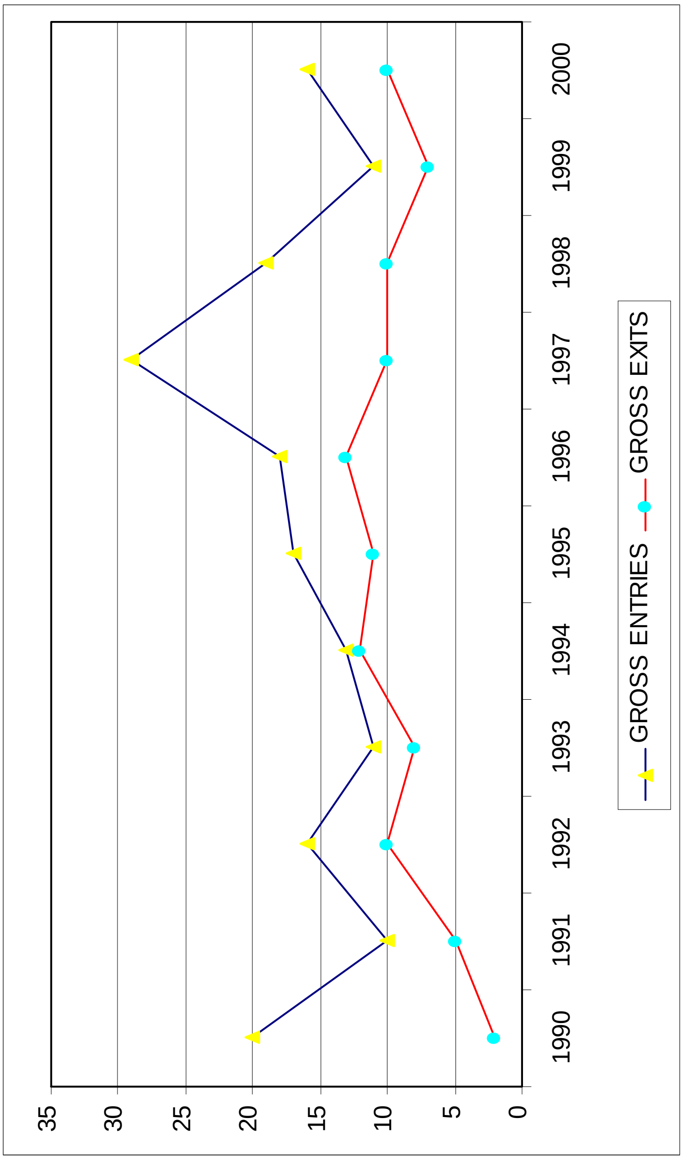


Figure 1: Gross number of entries and exits

Figure 2: Economic origin of producers in proportions by segment

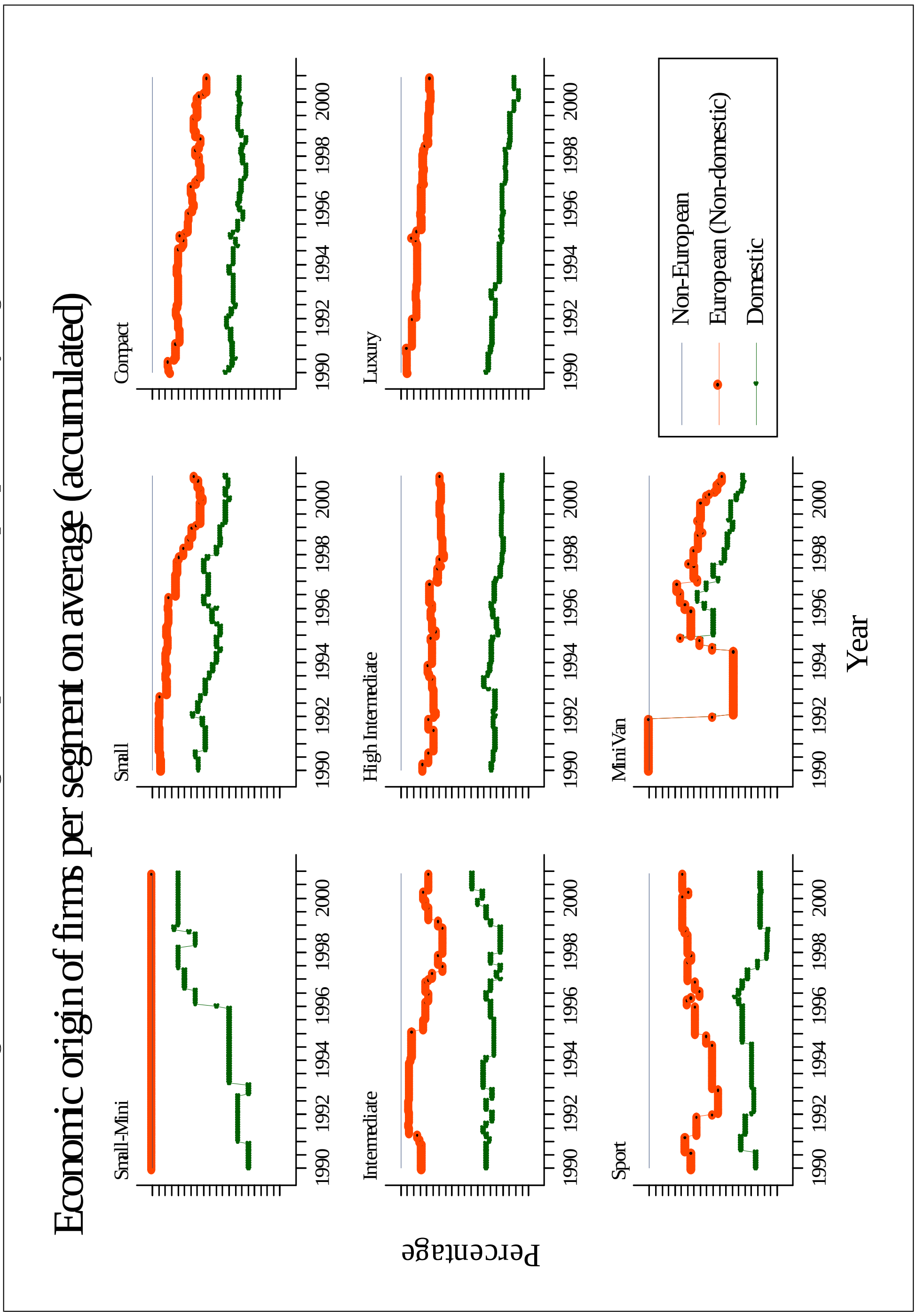


Figure 3: Number of Models by year and Manufacturer

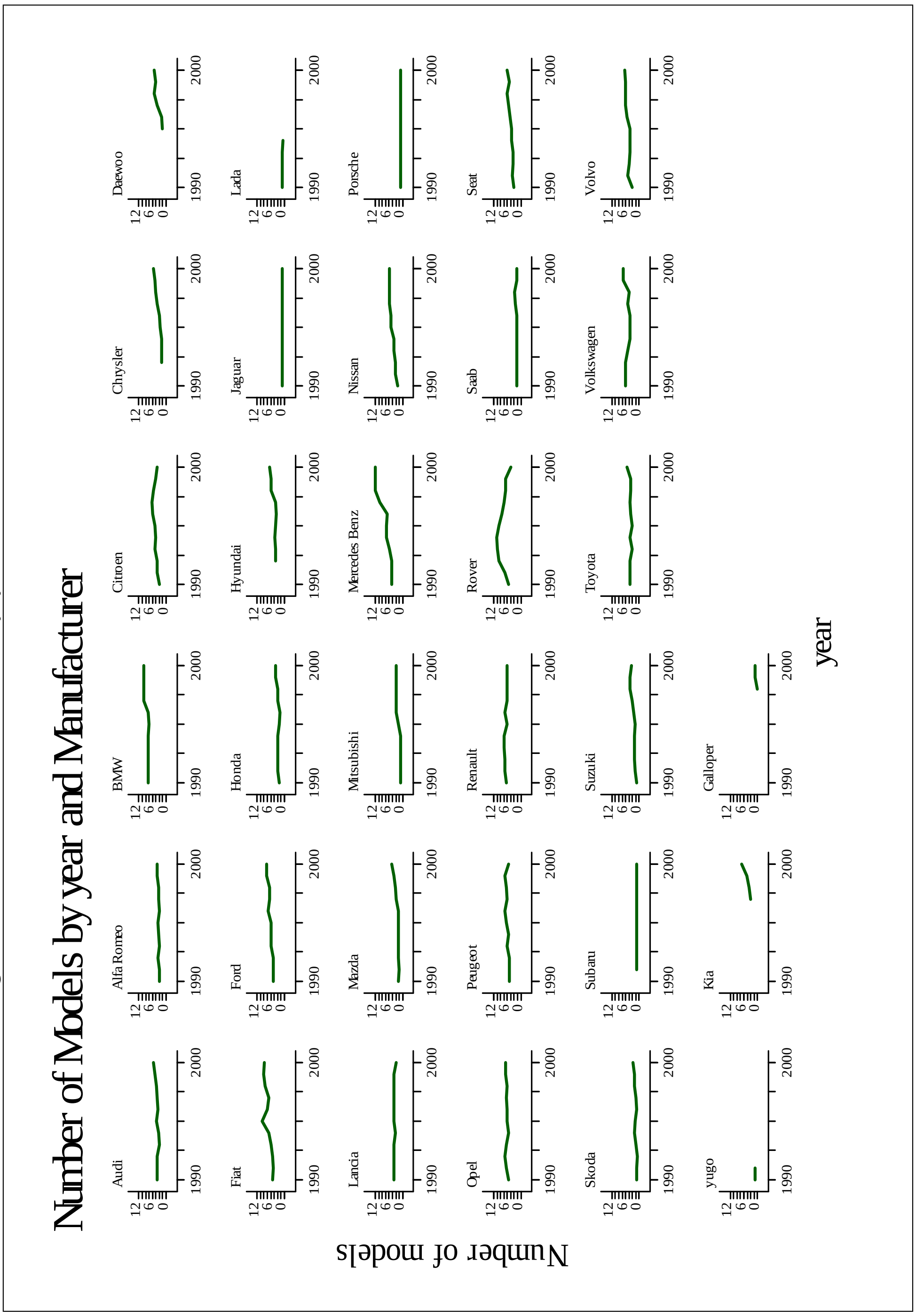


Figure 4: Evolution of the number of models per segment

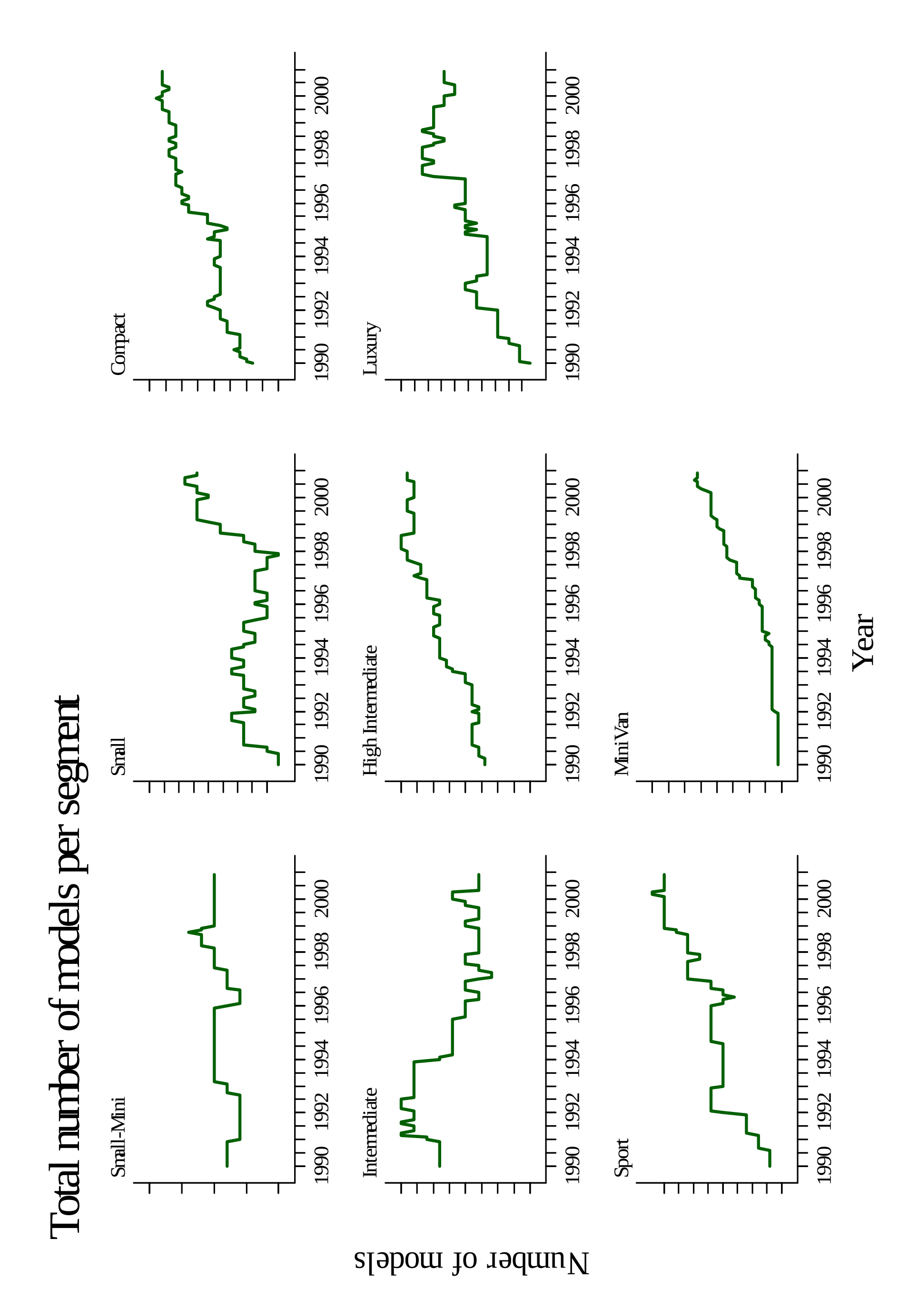
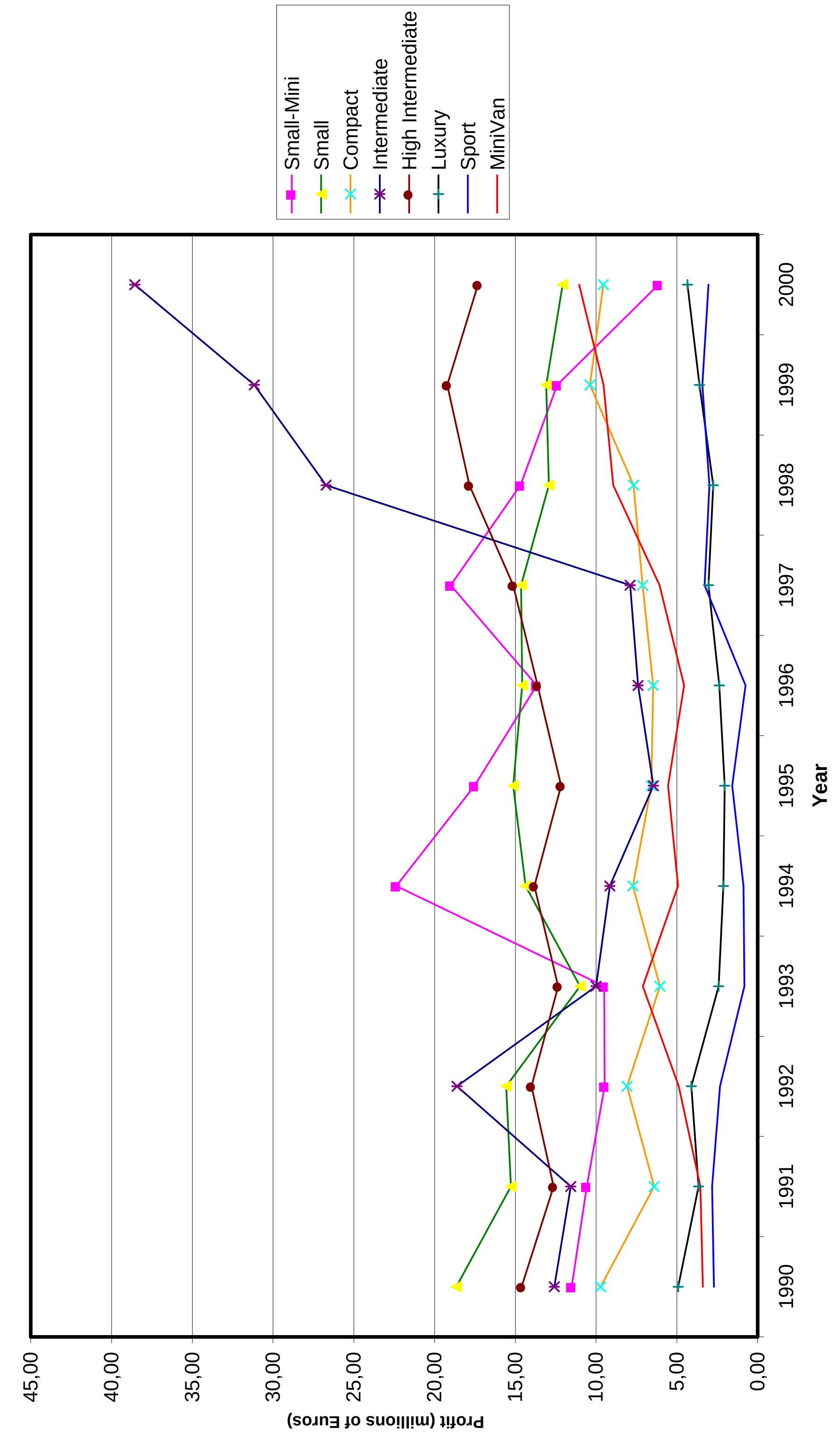


Figure 5: Average estimated profit by segment and year



Chapter 4

Entry Costs and Economies of Scope in Multiproduct Firms' Market Decisions: The Case of the Spanish Automobile Industry

4.1 Introduction

This chapter studies the costs of product introduction and commercialization in differentiated product markets from a dynamic point of view, with an application to the Spanish automobile industry in the 1990's. This market displays significant rates of entry and exit during that decade and is characterized by the existence of multiproduct firms that compete segment by segment with, usually, one model per segment.

Car producers are mostly multinational firms making decisions at the global industry level, namely, the development of new products. However, one thing is the R&D effort made to expand or improve the range of products and another is to choose the precise moment to implement those improvements. The decision to develop new products is made at the global level but the decision to introduce new products in Spain is made at the Spanish level. Even though the concept of region for a multinational firm may exceed the boundaries of a country, the empirical evidence shows that significant differences arise in the entry and exit of identical products across markets[1]. The intuition is that, apart from the R&D

[1] See chapter 2.

costs, the effective implementation of a new product depends on market-specific factors, namely on the commercialization side. Demand conditions, regional or national tastes for characteristics, etc. can render a product successful in one given market while it fails in another. In this chapter, I argue that incumbent firms have advantages in commercialization that make it easier for them to introduce new products compared to entrant firms. In particular, I look at the advantages when expanding the range of products: the conjecture is that a firm finds it easier to introduce a new variety of product (say a car in a new segment) when it already has other types of cars. The results give support to that claim and serve also to explain product proliferation in the industry.

Panzar and Willig coined the term "economies of scope" to describe cost savings that arise when the production of two or more product lines is combined, instead of being produced by separate firms (Panzar and Willig (1981)). Since then, many papers have been devoted to the measurement of economies of scope in different economic sectors like banking or hospitals. These approaches are based on the estimation of cost functions for multiproduct firms. However, they have a productive perspective in the sense they care only about cost savings from joint production, neglecting the costs of introducing those products. In industries like the auto industry, where the development and effective introduction of new products involves large costs in engineering, production, marketing, commercialization, and distribution, the omission of entry costs can give rise to misleading conclusions. For example, imagine two products whose joint production implies cost savings but only the first one exists and the second can only reach the market if large sunk costs in R&D or advertising are made. In that case, any productive advantage may be overwhelmed by entry costs.

In this chapter, I look at the economies of scope of product introduction abstracting from other scope economies. The model does not intend to explain scope economies in R&D, production, or plant activity. It intends to quantify the commercial advantage that a firm gets after it enters a market for the first time as the difference between the entry costs of subsequent products. I consider only economies of scope within the firm, i.e., product entry by a firm's competitors may have market enlargement and business stealing effects, but this is not supposed to affect a firm's entry costs. The commercial advantage may reflect brand image, continued advertising, development of dealer networks, etc. The separation between economies of scope in production and commercialization can be made because, as mentioned above, there is evidence about non-simultaneous or sequential entry of new products across countries. This suggests that development and entry are separate stages of the game played by car manufacturers and that it is not because a firm is "faster" or "better" in R&D that it introduces a new model earlier in one market relative to other markets. It serves also to avoid economies of scope in production being captured by the measure of economies of scope in commercialization because each of them belong to a different stage.

In this way we can talk of scope economies in the commercialization of new products and give a measure of their importance, which is the main contribution of the paper.

Contrary to standard productive costs functions, entry costs have the special characteristic that they are paid only once, but their effects spread over future periods. Therefore, they must be treated differently from usual recurrent costs. For this purpose, and relying on the strand of literature starting from Ericson and Pakes (1995), I construct a model where multiproduct firms decide whether to introduce and quit products and potential entrant firms decide on entry. Product is differentiated in quality, which is allowed to exogenously vary over time at some cost. Product characteristics are summarized in a quality index representing the utility obtained by consumers. Finally, there is price competition. Firms play a game that lasts a (perhaps infinite) number of periods, differing from the classical “supergames” in that it is a single game, rather than the infinite replica of a multi-stage game.

The decisions of entry/exit and also the changes in quality have dynamic implications because they affect not only current payoffs but also future payoffs and actions. Therefore, they must be treated differently from static decisions, whose influence is limited only to the period in which they are made, with no further repercussion. In my model, pricing is a static decision.

In the literature, there already are alternative methodologies dealing with the estimation of dynamic models. However, there are just a few empirical works on the topic that either focus on homogeneous product markets or go into a limited degree of differentiation. Compared to these works, the multi-product perspective of this paper calls for a clear distinction between firm entry cost and product introduction cost in the modeling strategy.

The structure of the paper is the following: in the next section I review the literature on entry and dynamic models. Then I present the model. In Section 4 I detail the estimation strategy. Section 5 describes the database used. Section 6 presents the results and further details. I conclude in Section 7.

4.2 Literature Review

The topic of entry and exit in automobile markets has been addressed from different perspectives. For example, Geroski and Murfin (1991) examine entry patterns across three segments of the U.K. car industry. They develop a probit model of the entry decision where post-entry profits depend on post-entry advertising shares. They find evidence that prior experience in the market may have had a small effect on entry in a particular segment. Geroski and Mazzucato (2001) study the relation between entry and advertising in the US automobile market. Requena-Silvente and Walker

(2005) study how model survival in the UK car market relates to competition. They find that inter-firm competition determines survival of sports and luxury models while intra-firm competition is determinant for the rest. However, these works are based on the estimation of reduced form models, a usual characteristic in the earlier papers in this literature. Regarding the Spanish market, the focus has been on testing pricing behavior (Jaumandreu and Moral (2006)) or on the role of advertising (Barroso (2007)).

The first structural works of entry proposed multi-stage game theory models (see Toivanen and Waterson (2000) for a review). However, static models are not able to capture the intrinsic dynamic nature of entry costs. The framework proposed by Ericson and Pakes (1995) and recently revised by Doraszelski and Satterthwaite (2007) has become the standard way to model dynamic oligopolies. I follow their approach in building up my model. Nevertheless, the large computational costs in solving for an equilibrium of those models has limited the range of empirical applications. Recent methodological developments (Aguirregabiria and Mira (2007); Bajari, Benkard, and Levin (2007); Pakes, Ostrovsky, and Berry (2007); Pesendorfer and Schmidt-Dengler (2007)), which make it possible to estimate the structural dynamic parameters without solving for an equilibrium, have boosted the literature on applied dynamic oligopoly models. The topics covered include firm entry and exit in homogeneous good markets (Ryan (2006); Collard-Wexler (2006)), entry in geographic markets (Dunne, Klimek, Roberts, and Xu (2006)), entry and competition in local retail markets (Aguirregabiria and Mira (2007)), and horizontal location of firms (Sweeting (2007)). So far, there has been no previous attempt to estimate product introduction costs by multiproduct firms, and the applications to the automobile industry focus only on the relation between market structure and innovation (Hashmi and Van Biesebroeck (2007)). To the best of my knowledge, the concept of scope economies defined in Panzar and Willig (1981) has not been used to provide a rationale for firms' product introduction and product proliferation strategies.

4.3 The Model

The i^{th} firm maximizes the discounted sum of expected profits from the sum of its N_{it} products (indexed by j); N_t is the total number of products at t:

$$\Pi_i = E\sum_{t=0}^{\infty}\sum_{j}^{N_{it}}\delta^t\pi_{ijt} \quad , \quad \forall\ i = 1, ..., N_t \tag{1}$$

A common discount factor δ is assumed for all firms. Variable profits are given by:

$$\pi_{ijt}^{var} = (p_{ijt} - c_{ijt})\, D_{ijt}\,(P_t, K_t)$$

Individual demand depends on the vector of all competing product prices and characteristics:

$$\begin{aligned} P_t &= (p_{1t}, ..., p_{N_t t}) \\ K_t &= (k_{1t}, ...k_{N_t t}) \end{aligned}$$

k_{ijt} is a quality index summarizing product characteristics (excluding price). I do not consider the problem of choosing characteristics in a multidimensional framework, hence each product is just a bundle of diverse features added up using a hedonic weight, γ_q , for each one:

$$k_i = \gamma_1 k_{i1} + \gamma_2 k_{i2} + ... + \gamma_q k_{iq} \tag{2}$$

I assume that products are exogenously classified in segments (groups). Then following Berry (1994), demand is modeled using a standard nested logit model:

$$D_{it}\left(P_t, K_t\right) = S_{it}\left(P_t, K_t\right) * M_t$$

$$S_{ijt} = \frac{\exp\left(\frac{k_{ijt}-\alpha p_{ijt}}{1-\sigma}\right)}{\sum\limits_{j\in G_g}\exp\left(\frac{k_{ijt}-\alpha p_{ijt}}{1-\sigma}\right)} \frac{\left[\sum\limits_{j\in G_g}\exp\left(\frac{k_{ijt}-\alpha p_{ijt}}{1-\sigma}\right)\right]^{1-\sigma}}{1+\sum\limits_{g=1}^{G}\left[\sum\limits_{j\in G_g}\exp\left(\frac{k_{ijt}-\alpha p_{ijt}}{1-\sigma}\right)\right]^{1-\sigma}}$$

where M_t is the market size and $S_{ijt}\left(\cdot\right)$ is the share of product j. I also assume a constant marginal cost of production, c_{ijt}.

There is a product specific cost[2], $F\left(k_{ijt}, i_{ijt}\right)$, of implementing a quality index k_{ijt} with quality change i_{ijt} .

4.3.1 State Variables and Controls

I describe here the state space of the model. I try to represent it in a parsimonious way, although this requires making some simplifications. I comment on them as I describe each element of the state space.

In period t , the controls are the decisions of entry and exit $\left(\chi_{ijt}\right)$ and the decision of whether to invest. Entry and exit determine the number of products at the beginning of $t+1$. Therefore, N is an endogenously evolving state variable. However, market shares do not depend directly on the number of products. The larger the number of competitors, the less likely a particular product is consumed because there are more potential options that can give more utility. Thus, N_t influences

[2]The cost of change is just the cost of adapting the product to the new specification (and not the cost of developing it), e.g., the cost of adapting the car to embody a more powerful engine, or perhaps the cost of adapting the productive chain of that model. It is true that in order to use a more powerful engine, it must first be designed and developed. In this stage, spillovers arise within multiproduct firms, which can make it easier to develop new engines for other models. These are the scope economies in production (or R&D), but I am looking only to scope economies in commercialization.

shares through the pair (K_t, P_t)[3]. An alternative way of considering the number of competitors would be to split N into its components: number of products in the segment and number of products in other segments. The former may capture the incentives for product exit in a segment as a consequence of competition. The latter could reflect the incentives for product entry in new segments to relax competition.

The total number of firms is fixed and known. They may be incumbents or potential entrants. Candidate products not introduced are discarded and in the following period a new set of products will be available for entry. There is an implicit but important assumption, which is that every period the feasible set of products for a firm is somehow "given". The decisions of entry are made on these products. This first stage where products become available is not modelled. This caveat is partially justified in the application I have in mind: product entry in a national market by a global firm, where R&D is made at the global level, so that every period a range of products becomes available worldwide but the decision of entry is made independently in each national market. Needless to say, the ideal model should account for that stage as well.

Initial quality is given by initial product characteristics, which are drawn from some distribution and then aggregated to form the index, whose initial value is thus random. Given that I am not modelling the choice of characteristics and I only need the quality index, it is in fact simpler to assume randomly drawn initial quality, understanding that it is linked to characteristics through equation (2). Firms modify quality as time goes by. The amount of change, if any, is exogenously given. The model does not deal with choice of characteristics and, as noted above, when they vary I assume they do it in exogenous amounts. However, the decision of modification is endogenous because the firm can always keep the product "as is"

[3] In my model, we can only have a direct effect of the number of incumbents over market shares when all firms offer the same pair (k, p) , then: $S_{ijt} = \frac{\exp\{k-\alpha p\}}{1-N*\exp\{k-\alpha p\}}$.

without modifications. Therefore, the model can explain entry and exit decisions controlling for the empirical fact that quality is changing over time. In the context of product differentiation, it is necessary to keep track of product characteristics even though we are only interested in the entry-exit process, because characteristics define products. Notice that quality changes are an alternative to product replacement, but if the cost of those changes is too high, firms may prefer to quit the product.

The dimension of K becomes large as the number of products increases and this poses a problem in estimation because the state space is too large. Therefore, I consider an alternative representation of the state space in the spirit of Weintraub, Benkard, and Van Roy (2007), where for each product the state is defined by its quality index, the average quality index $\bar{K}$, and the number of competing products. Likewise, I do not include market size or demand conditions in the state space.

4.3.2 Timing

Each firm receives a private draw from the distribution of sunk costs of entry/sell-off values (depending on whether it is an entrant or an incumbent) and decides χ_{ijt}. If a firm does not quit the product, it receives an exogenous shock that determines whether the quality of the good is going to be changed or not. Entrants can immediately start to sell their product; exiting firms receive their scrap value and disappear. Given the new (K_t, N_t), firms simultaneously set prices and receive variable profits. The important thing here is that firms cannot change k_{ijt} or χ_{ijt} when they are about to compete in prices. Shocks happen before decisions are made and are the key to rationalizing the variability of decisions from firms with the same observed features.

4.3.3 Decision Rules

Firms make several decisions every period. An incumbent firm decides, for each segment, whether to introduce a new product or not. If it has no product in a segment, that decision is equivalent to entering or not entering that segment. If it already has other product(s) in the segment, then it can decide whether to quit any of them. Firms that are out of the market may decide to enter or not. Entry may take place in more than one segment at the same time. Firms are allowed to introduce at most one new product per segment and period, but they can quit as many products as they have. There is a maximum for the number of products a firm can commercialize in each segment. Enter/Not enter decisions are represented by the indicator $\chi^e_{ijt} = \{0, 1\}$ and stay/exit by $\chi_{ijt} = \{0, 1\}$. After all firms have decided about entry and exit, products are modified if necessary. Finally, there is price competition.

Entry/Stay/Exit Every period each incumbent (entrant) receives a shock from a known distribution on the sell-off value (sunk cost of entry), ϕ (κ). If the discounted sum of expected payoffs is smaller than that draw, the firm exits (does not enter), i.e.:

$$\begin{aligned}
\chi_{ijt} &= 0 \Longleftrightarrow EDV_t^{incumbent}\left(K_{t-1}, N_{t-1}\right) \leq \phi \\
\chi^e_{ijt} &= 0 \Longleftrightarrow EDV_t^{entrant}\left(K_{t-1}, N_{t-1}\right) \leq \kappa
\end{aligned}$$

where $EDV_t^{incumbent}\left(K_{t-1}, N_{t-1}\right)$ and $EDV_t^{entrant}\left(K_{t-1}, N_{t-1}\right)$ represent the expected discounted sum of payoffs for an incumbent and an entrant, respectively, conditional on staying/entering at t given (K_{t-1}, N_{t-1}). I assume that when a firm quits a product, it can never re-enter. Instead, it may introduce a new product. Also, all firms decide χ_{ijt} simultaneously. These are dynamic decisions because their effects spread over a number of periods.

Pricing This is a static decision: p_{ijt+s} is not a function of p_{ijt+1} $\forall\ s \neq 1$. Pricing decisions become determined by the state variables and Bertrand competition. Therefore, prices are irrelevant in the dynamic problem and they can be substituted by their optimal expressions in the one-period payoff function.

Given k_{ijt} and N_t, p_{ijt} is chosen so as to maximize the profit stage. As I argued above, this is a "self-contained" decision and I can substitute back in the one-period payoff function to obtain a reduced form:

$$\pi_{it} = \pi_{it}\left(K_t, N_t\right)$$

It can be shown that the first-order condition of a multiproduct firm in a nested logit is:

$$\begin{aligned}\left(p_j - c_j\right) S_j &= \frac{1-\sigma}{\alpha} S_j + \sigma S_{j/g} \sum_{j \in G_g} \left(p_j - c_j\right) S_j \\ &\quad + \left(1-\sigma\right) S_j \sum_{g \in G} \sum_{j \in G_g} \left(p_j - c_j\right) S_j \quad, \forall j, \forall g\end{aligned}$$

From this system of FOC's, it is possible to obtain an equilibrium expression of product variable profit as a function of the state variables:

$$\begin{aligned}\pi_j^{var}\left(K_t, N_t\right) &= \frac{1-\sigma}{\alpha} S_j\left(K_t\right) M + \sigma S_{j/g}\left(K_t\right) \pi_{ig}^{var}\left(K_t, N_t\right) \\ &\quad + \left(1-\sigma\right) S_j\left(K_t\right) \pi_i^{var}\left(K_t, N_t\right) \quad, \forall j, \forall g\end{aligned}$$

where α is the marginal utility of income, σ is the degree of intra-group correlation and $S_{j/g}$ is the market share of j conditioned to group g. π_{ig}^{var} is the variable profit of firm i in segment g, and π_i^{var} is the total profit of firm i:

$$\pi_{ig}^{var} = \frac{(1-\sigma)\sum\limits_{j\in G_g} S_j}{1-\sigma\sum\limits_{j\in G_g} S_{j/g}} \left[\frac{M}{\alpha} + \pi_i^{var}\right] \qquad , \forall g$$

$$\pi_i^{var} = \frac{M\sum\limits_{g\in G_g} \frac{1}{\alpha}\frac{(1-\sigma)\sum\limits_{j\in G_g} S_j}{1-\sigma\sum\limits_{j\in G_g} S_{j/g}}}{1-\sum\limits_{g\in G}\frac{(1-\sigma)\sum\limits_{j\in G_g} S_j}{1-\sigma\sum\limits_{j\in G_g} S_{j/g}}}$$

Notice that there is an implicit, non-linear, one-to-one relationship between p and k. p is determined with no direct influence of the shock ε, although p is affected by ε through k.

Characteristics As discussed above, firms modify product characteristics in response to exogenous changes. When this happens, firms adjust product quality to a new level such that:

$$i_{ijt} = k_{ijt} - k_{ijt-1}$$

i_{ijt} can be interpreted as the change of value of product j in hedonic terms. This is a deterministic law of motion for k_{ijt}; what is random is the decision to change product specification.

Summarizing, the one-period payoff function is given by:

$$\begin{aligned}\pi_{it} &= \sum_{j=1}^{N_{it}} \chi_{ijt}\left[\left(p_{ijt}-c_{ijt}\right)S_{ijt}M_t + \rho\mathbf{1}\left(i_{ijt}\neq 0\right)\left(F\left(k_{ijt}, i_{ijt}\right)+\varepsilon_{ijt}\right)\right] \\ &\quad -\chi_{ijt}^{e}\kappa_{ijt}^{e} + \left(1-\chi_{ijt}\right)\phi_{ijt} \qquad (3)\end{aligned}$$

where $1\,(inv \neq 0)$ is an indicator function whose value is zero if investment is zero, and one otherwise. Notice that $\chi^e = 1 \Longrightarrow \chi = 1$ and $\chi = 0 \Longrightarrow \chi^e = 0$. A model that is in the market and continues is represented by $\chi = 1, \chi^e = 0$. $\chi^e = 1, \chi = 0$ is not possible.

The profit from a product continuing in the market is:

$$\pi_{ijt}\left(K_t, N_t^I\right) = \pi_j^{var}\left(K_t, N_t\right) + \rho\mathbf{1}\left(inv \neq 0\right)\left(F\left(k_{ijt}, i_{ijt}\right) + \varepsilon_{ijt}\right) \tag{4}$$

π_{ijt} depends on K_t in a highly non-linear way through market shares.

4.3.4 Bellman Equation

The Bellman equation of the problem can be written as:

- For an incumbent:

$$V_{ij}\left(K_{t-1}, N_{t-1}\right) = \max\left\{\phi_{ijt}\ ,\ \max_{i_{ijt}}\left\{\begin{array}{c}\pi_{ijt} + \beta\int V_{ij}\left(K_t, N_t\right)\\ dG_K\left(K_t|K_{t-1}\right)dG_N\left(N_t|N_{t-1}\right)\end{array}\right\}\right\}$$

  and π_{it} is given by (4).

- For a potential entrant:

$$V_{ij}\left(K_{t-1}, N_{t-1}\right) = \max\left\{0\ ,\ \max_{i_{ijt}}\left\{\begin{array}{c}-\kappa_{ijt} + \pi_{ijt} + \beta\int V_{ij}\left(K_t, N_t\right)\\ dG_K\left(K_t|K_{t-1}\right)dG_N\left(N_t|N_{t-1}\right)\end{array}\right\}\right\}$$

  and π_{ijt} is given by (4). Notice that the entrant incurs the cost κ_{ijt} right after entry, and it can immediately start to sell the product.

G_K and G_N are the distribution functions giving the transition probabilities of K and N, respectively.

4.3.5 Equilibrium Concept

Firms make decisions with an infinite horizon and so the potential number of Nash equilibria (NE) is likely to be large, involving complex combinations of decision rules. Therefore, I consider a restricted class of NE, the pure strategy Markov perfect equilibria (MPE), by assuming firms play Markov strategies, which means that strategies depend on all payoff relevant history. Formally, a Markov strategy is a map from the state space to the action space:

$$\sigma_{ijt} : K_t \times N_t \longrightarrow A_{ijt}$$

such that:

$$\sigma_{ijt}\left(K_{t-1}N_{t-1}, K_{t-2}, N_{t-2}, K_{t-3}, N_{t-3}, ...\right) = \sigma_{ijt}\left(K_{t-1}, N_{t-1}\right)$$

Let's define a profile of Markov strategies as the vector:

$$\sigma_t = (\sigma_{1t}, ..., \sigma_{N_t t})$$

Following Ackerberg, Benkard, Berry, and Pakes (2005), we can say that a Markov strategy profile, σ, is an MPE if for all ij, all states, and all Markov strategies, σ'_{ij}:

$$V_{ij}\left(K, N \mid \sigma_{ij}, \sigma_{-ij}\right) \geq V_{ij}\left(K, N \mid \sigma'_{ij}, \sigma_{-ij}\right)$$

Doraszelski and Satterthwaite (2007) (DS) show the existence of (at least one) MPE in an Ericson and Pakes (1995) setting like mine. In particular, proposition 1 in DS shows that an MPE equilibrium exists in cutoff entry-exit and pure investment strategies under three assumptions. Assumption 1 states boundness of the model's primitives (finite state space, bounded profits and investment, continuity and bounded support of entry costs and scrap values, and discounting). Assumption 2 is basically a continuity assumption in payoff functions. Assumption 3 requires that a firm's investment choice is always uniquely determined. The first two are standard assumptions easy to verify. The third one is a bit more restrictive, but not a big issue in my model. I consider exogenously determined investment with one unique investment level for each state and this is optimal provided the policy function has been accurately recovered.

I assume that if there is more than one equilibrium, then the data is generated from only one of them.

Therefore, the value function can be written in recursive form:

$$\begin{aligned} V_{ij}\left(K,N|\sigma\right) &= \pi_{ij}\left(\sigma\left(K,N\right),K,N\right) \\ &+\beta\int V_{ij}\left(K',N'|\sigma\right)dG_K\left(K'|\sigma\left(K,N\right),K\right)dG_N\left(N'|\sigma\left(K,N\right),N\right) \end{aligned}$$

4.4 Estimation Strategy

In this section, I follow the two-step methodology developed in Bajari, Benkard, and Levin (2007) (BBL). In the first step, the goal is to estimate policy functions and all parameters not involved in the dynamics of the problem. These allow the simulation of alternative histories for the industry which are then used in the second step to recover the dynamic parameters and value function estimates in equilibrium.

4.4.1 First Stage

The target parameters here are those from market demand, variable profit function, investment, and entry/stay/exit decision rules.

Variable static profits are computed by making use of the equilibrium expression obtained from the logit specification:

$$\pi_{ijt}^{var} = \frac{1-\sigma}{\alpha} S_{ijt} M + \sigma S_{j/g} \pi_{ig}^{var} + (1-\sigma) S_{ijt} \pi_i^{var} \tag{5}$$

α is the marginal utility of income, obtained from demand estimation, M_t is (observed) market size, and π_{ig}^{var} and π_i^{var} are functions of market shares defined above. Therefore, the key element is the estimation of market shares, which is discussed below.

As I handle a reduced form of variable profits where marginal cost is substituted away, I do not have to be concerned about estimating variable production costs.

The policy functions for entry and exit are kept simple (as, for example, in Ryan (2006)). I model the probability of firm i introducing a new model j at time t in segment g, conditional on the number of models of the firm N_i, as a function of the number of models it has in other segments, $N_{i,-g}$, and on the average quality in the segment, $Avksg$. (Other measures of the number of competitors were considered, but their coefficients had significance problems).

The dimension of the state space would require a lot of data to be able to estimate the policy function parameters for each combination of quality for all competing models. This is why I consider the average quality in the segment as a proxy for the vector of product qualities. For the same reason, I consider the number of models instead of the particular portfolio of the firm's products. This is to say that, for example, the decision of entry of the third, large model having a small and a mini is equivalent to having a medium and a mini. The implicit assumption under these two simplifications is that I am still able to recover the optimal policies coming from the equilibrium of the model.

Using Bayes' rule:

$$prob\left(entry_{ijt}|N_{it}\right) = \frac{\Pr\left(N_{it}|entry\right) * \Pr\left(entry\right)}{\Pr\left(N_{it}|entry\right) * \Pr\left(entry\right) + \Pr\left(N_{it}|no\ entry\right) * \Pr\left(no\ entry\right)}$$

where $\Pr\left(N_{it}|entry\right)$ and $\Pr\left(N_{it}|no\ entry\right)$ are modeled using ordered probits:

$$\Pr\left(N_{it} = 0 \mid entry\right) = F_n\left(c_1 - \beta_1 * N_{i,-g,t-1} - \beta_2 * Avksg_{gt-1}\right) = F_n\left(c_1 - x\beta\right)$$

$$\Pr\left(N_{it} = n \mid entry\right) = F_n\left(c_{n+1} - x\beta\right) - F_n\left(c_n - x\beta\right) \quad , \quad n = 1, ..., N-1 \qquad (6)$$

$$\Pr\left(N_{it} = N \mid entry\right) = 1 - F_n\left(c_N - x\beta\right)$$

where the $c's$ are the cutoffs determining when each category is chosen. The same is done for $\Pr\left(N_{it}|no\ entry\right)$. The $\Pr\left(entry\right)$ is estimated as the sample rate of entry. I decompose the conditional probability of entry in the reverse conditional probabilities because for some N there are few observations on entry and this poses some difficulties in the estimation. The $\Pr\left(N_{it} = n \mid entry\right)$ and $\Pr\left(N_{it} = n \mid no\ entry\right)$ turn out to be easier to estimate and simplify the computations for the second stage. For this reason, here I have not considered other smoothing or interpolation techniques such as kernels or splines.

The probability of exit is modeled using a probit on the deviation of k with respect to its segment mean (a parsimonious way of modelling the relation of product j with its competitors), the number of models of the firm in the segment, $N_{ig,t-1}$, and the age of the firm's oldest product in the segment, $maxage_{ig}$:

$$prob\left(exit_{it}\right) = F_n\left(\beta_0^x + \beta_3 * N_{ig,t-1} + \beta_4 * maxage_{igt-1} + \beta_5 * DevkSg_{ijt-1}\right) \qquad (7)$$

The state space increases as the number of products becomes large. It is necessary to reduce the dimension of the state space to be able to estimate the policy functions, because it is not possible to estimate one parameter for each element of vector K. I overcome this by considering the average quality, instead of the vector of qualities, in the entry and exit probits. Moreover, the large number of zeros in the entry and exit decisions can pose some identification problems in those equations unless some exclusion restriction is imposed. For this reason I add *maxage* as an explicative variable in the exit equation. This variable is a proxy for the degree of obsolescence of the product and it serves as a complement to k_j (which is included within $DevkSg$).

The different approach for entry and exit policies is because we are interested in how the entry cost changes as the number of models of the firm increases. Therefore, the entry policy must be sensitive to that fact while the exit policy can be more parsimonious.

Quality changes are modeled in the following manner. The probability of change depends on the current level of k and its deviation with respect to the mean of the segment. The firm is shocked by an exogenous cutoff such that if the probability of change is larger, then the quality of the product is adjusted. I use a probit for the probability of change:

$$prob(invest) = F_n\left(\beta_0^{inv} + \beta_6 * k_{ijt-1} + \beta_7 * DevkSg_{ijt-1}\right) \tag{8}$$

The quality adjustment is given by a cubic B-spline policy on the deviation of k_j with respect to its segment mean:

$$i_{it} = \beta_8 * Sp\left(DevkSg_{ijt-1}\right) \tag{9}$$

This setup allows for a better fit of the observed quality changes.

I model the adjustment cost function as an exponential of the absolute value of the change in characteristics, and zero when investment is zero:

$$F\left(k_{jt}, i_{jt}\right) = \mathbf{1}\left(i_{ijt} \neq 0\right) * \exp\left(abs\left(i_{ijt}\right)\right)$$

I obtain the estimates for all the α, σ, c, and β parameters. Then I can generate a set of simulated paths from different initial conditions and confront them with perturbed, non-optimal paths to obtain the estimates of the dynamic parameters of the model in the second stage.

4.4.2 Second Stage

The second stage deals with the estimation of dynamic parameters (investment cost, scrap value, entry costs). Given the actual and simulated paths for the industry, the estimation goes as follows: recall the equilibrium condition

$$V_{ij}\left(K, N \mid \sigma_{ij}, \sigma_{-ij}\ ;\ \theta\right) \geq V_{ij}\left(K, N \mid \sigma'_{ij}, \sigma_{-ij}\ ;\ \theta\right)$$

Recall that from equation (3), the one-period payoff function is linear in the dynamic parameters and then $V(\cdot)$ is linear in θ:

$$\begin{aligned} V_{ij}\left(K, N; \sigma_{ij}, \sigma_{-ij}; \theta\right) &= E\left[\sum_{t=0}^{\infty} \delta^t \Psi_{ijt}\left(\sigma_{ijt}, K_t, N_t, \nu_{ijt}\right) \middle| K_0 = K, N_0 = N\right] \cdot \theta \\ &= W_{ij}\left(K, N; \sigma_{ij}, \sigma_{-ij}\right) \cdot \theta \qquad (10) \end{aligned}$$

where $\Psi_{ijt}(\cdot) = \left(\pi_{ijt}^{var}(K)\ ,\ F\left(k_{ijt}, i_{ijt}\right)\ ,\ \phi_{ijt}\right)$ is the vector of basis functions for payoffs and $\theta' = (1, \rho, \phi)$; then the equilibrium condition becomes:

$$\left[W_{ij}\left(K, N \mid \sigma_{ij}, \sigma_{-ij}\ \right) - W_{ij}\left(K, N \mid \sigma'_{ij}, \sigma_{-ij}\right)\right] \cdot \theta \geq 0 \qquad (11)$$

Let $x \in X$ be an index for the equilibrium conditions such that each x represents a combination of product, alternative action, and states, $\left(ij, K, N, \sigma'_{ij}\right)$. Then each condition (11) of the set of inequalities X can be rewritten as

$$g(x;\theta) = \left[W_{ij}(K, N; \sigma_i, \sigma_{-i}) - W_{ij}\left(K, N; \sigma'_{ij}, \sigma_{-ij}\right)\right] \cdot \theta \tag{12}$$

The vector of dynamic parameters θ satisfies an equilibrium condition defined by x if $g(x;\theta) \geq 0$. Therefore, the estimation strategy consists in taking many such conditions and finding a θ such that profitable deviations from the optimal policies (represented by $g(x;\theta) \leq 0$) are minimized. For this purpose, define the function

$$Q(\theta) = \int \left(\min\left\{g(x;\theta), 0\right\}\right)^2 dH(x)$$

where $H(\cdot)$ is a distribution over the set of inequalities, X, which the g conditions belong to. At the true parameter value, $Q(\theta_0) = 0 = \min_{\theta} Q(\theta)$, i.e., the objective function is minimized at θ_0. Its empirical counterpart can be written as:

$$Q_n(\theta) = \frac{1}{n_I} \sum_{k=1}^{n_I} \left(\min\left\{\tilde{g}_k(x;\theta), 0\right\}\right)^2 \tag{13}$$

where the $\tilde{g}_1, ..., \tilde{g}_{n_I}$ is a set of n_I inequalities drawn from $H(\cdot)$. $\tilde{g}$ is the sample counterpart of g that results from replacing W_{ij} with simulated estimates $\hat{W}_{ij}$.

Following the methodology of BBL, I randomly draw the n_I inequalities to construct (13). Then I compute W_i for the observed and alternative policies using observed and simulated industry paths. Alternative policies are generated by adding small, random perturbations to the policy functions. The W_{ij}'s are used to obtain the $\tilde{g}_k(\cdot)$'s. Finally, $Q_n(\cdot)$ is minimized in θ for the non-positive $\tilde{g}_k(\cdot)$ conditions using standard optimization procedures. BBL show that under some regularity assumptions, $\hat{\theta}$ is consistent for θ.

Entry Costs Once the vector of dynamic parameters, $\hat{\theta}$, is obtained, it is possible to estimate the distribution of sunk costs of entry in a simple manner: for each relevant state configuration, simulate the expected discounted value of entry (EDV) for an entrant at that state. Also compute the probability of entry using the entry policy. We know that firms enter only if the EDV is not smaller than the sunk cost of entry; if we match this with the predicted probability of entry, we obtain the following relationship:

$$prob(entry|N) = prob\,(\kappa \leq EDV; \lambda) = F\,(EDV; \lambda)$$

i.e., the observed probability of entry is the value of the cumulative density function evaluated at EDV. I assume a normal distribution for F and I minimize the squared distance between both parts of the equation:

$$\min_{\mu,\sigma_e} \frac{1}{ne} \sum_{i=1}^{ne} \left[prob_i\,(entry|N) - F\,(EDV_i)\right]^2 \tag{14}$$

where ne is the number of states for which the EDV of entry is computed. With μ and σ, the distribution of sunk entry costs is characterized under the assumption of normality.

This basic procedure can be used to estimate different types of entry costs. In particular, the model allows us to compute EDV's and entry costs for:

- Firm entry (the entrant model belongs to a firm which has no other model in any other segment).
- Segment entry (the firm is in other segments but not in this one).
- Model entry (the firm is already in the segment and introduces a new model).

Case 1:

This is the simplest case described above. We can compute the empirical probability of entry using the policy function, and simulate the EDV starting from an industry configuration where this firm is not in the market.

Case 2:

In this case, the firm is already in and we want to estimate the cost of entering another segment. The number of possible industry configurations increases with respect to case 1 because the incumbent firm may have several models in other segments. For example, with a classification in 8 segments and a firm that has only one previous model, the number of alternatives with respect to case 1 multiplies by 7. If the firm already had 2 models, the number of alternatives is multiplied by $\binom{7}{2} = 21$, and so on.

Again, the empirical probability can be computed and the EDV's are computed for an industry configuration restricted in the appropriate manner.

Case 3:

The number of combinations is the same as case 1 or case 2 depending on the particular restrictions we want to impose on the firm. In particular, we could think of the cost of introducing the second product in the same segment and compare it to the cost of introducing it in another segment (as in case 2).

Estimation of Entry Cost Parameters and the Measure of Scope Economies

I argue that the entry cost is different depending on the number of models commercialized by the firm. This implies that, conditional on the number of models, all firms receive iid shocks from the same (normal) distribution over time, but this distribution changes as the number of models changes. I introduce a parametric restriction which is that all distributions have the same variance and they differ only in the mean. This implies that those distributions are shifted to the left or to the right as the number of models increases. Taking as a reference the entry cost with no previous products (firm entry), the existence of economies of scope in commercialization follows from these distributions shifting to the left (at least for a small number of products). Recall that the basic equation for sunk costs of entry is:

$$\begin{aligned} prob(entry) &= F_N\left(\kappa \leq EDV; \lambda\right) \\ prob(entry) &= F_N\left(\frac{\kappa-\mu}{\sigma_e} \leq \frac{EDV-\mu}{\sigma_e}\right) \end{aligned}$$

Consider for simplicity the case where we want to estimate the cost of firm entry and the cost of introducing a second and third product in other different segments. We can argue that they are different by factors d_1 and d_2 such that the mean firm entry cost is μ_0, the mean entry cost of a second product is $\mu_1 = \mu_0 + d_1$, and for the third product $\mu_2 = \mu_0 + d_2$. The above probability equation becomes:

$$prob\left(entry \mid N=1\right) = F_N\left(\frac{\kappa - d_1 - d_2 - \mu_0}{\sigma_e} \leq \frac{EDV - d_1 - d_2 - \mu_0}{\sigma_e}\right)$$

If the firm is about to introduce a third product:

$$prob\left(entry \mid N=2\right) = F_N\left(\frac{\kappa - d_1 - d_2 - \mu_0}{\sigma_e} \leq \frac{EDV - d_1 - d_2 - \mu_0}{\sigma_e}\right)$$

The firm entry cost can be identified from the variation in the observed rates of entry, the normality assumption, and the variation of present discounted values. For a given initial state, the entry policy function provides an estimate of the probability of entry. The forward simulation procedure yields the correspondent expected value of entry for that initial state. The quality adjustment cost parameter and the scrap value required in the forward simulation are also identified. These parameters are computed such that profitable deviations from optimal observed behavior, summarized in the policy functions, are minimized. Therefore, the variability in adjustment decisions, conditional on the state, and their difference with respect to the optimal ones identify the adjustment cost parameter such that the policy function is indeed optimal. A similar argument holds for the scrap value.

The identification of d's comes from the observed variation in the number of previous products of the firm. In practice, d should be estimated as the coefficient of a dummy for the number of firm models. For example, d_2 is the coefficient of the indicator variable $\mathbf{1}\left(\#models = 2\right)$. It is clear that this variable is zero in the first equation, but it is still good to include it because the joint estimation of μ_0 and d's is more efficient. The difference of entry costs in other scenarios can be captured by adding the corresponding dummy variables and computing the EDV for all the possible states involved.

4.5 Data

I apply the methodology described above to the Spanish car industry. I use a unique monthly data set of car models in Spain from 1990 to 2000. These data were initially collected by, and first used in Moral (1999)[4], who also provides a thorough description of the data base. It contains information on model characteristics such as speed, size, consumption, and horse power, among others. I also have the number of registrations by model and listed prices.

A descriptive look at the evolution of main characteristics (see Table 1) shows that, on average, we observe variation in at least one characteristic in roughly 60% of the sample of yearly observations (the ratio is obviously smaller when looking at monthly observations). Table 2 shows the percentage of variation by segment on a monthly basis for the same characteristics. Overall, the average variation across segments is 4.8%. This variability is also confirmed by casual observation of specialized press reports.

[4] The data base here, which runs from January 1990 to December 1996, has later been extended up to December 2000.

Table 3 summarizes entries and exits by segment: the rate of entry is around 17% per year per 9% of exit. The persistent gap is the reason for the increasing number of models in the industry during the 1990's.

I construct the index of characteristics of each model in the sample as a weighted sum whose weights are the estimated coefficients of each characteristic in the demand equation (in a sense, we could call that index a gross hedonic index as price is excluded and considered separately). The index can be interpreted as the average utility that a consumer could obtain from that product, without taking into account its price. Table 4 gives a summary of characteristics and prices per segment. The coefficients of the index are in Table 5.

4.6 Results and Further Details

4.6.1 First Stage Estimates

In this stage, I estimate demand and the policy functions for entry, exit, and investment.

Demand Estimation Using Nested Logit Following Berry (1994), we can write the shares equation as follows:

$$\ln\left(S_{jt}\right) - \ln\left(S_{0t}\right) = k_{jt} - \alpha_g p_{jt} + \sigma_g \ln\left(S_{jt/g}\right) + \eta_j \tag{15}$$

where the marginal utility of income (α) and the degree of intra-group correlation (σ) are allowed to vary across segments. $S_{j/g}$ is the market share of product j in its group g, η_j is an unobserved fixed effect, and the index of characteristics is constructed as:

$$k_{jt} = \gamma_1 Carsize_{jt} + \gamma_2 HP_{jt} + \gamma_3 KmL_{jt} + \gamma_4 AC_{jt} + \gamma_5 ABS_{jt}$$

The endogeneity of prices and conditional market shares is controlled for with the following instruments: following Berry, Levinsohn, and Pakes (1995) (BLP), as instruments I use product characteristics, the sum across own-firm products of each characteristic, and the sum across rival firms' products of each characteristic. I also include the total number of models per segment (as in Brenkers and Verboven (2006)), and finally the differences of prices with respect to their individual time means, $\tilde{p}_{jt} = p_{jt} - \frac{1}{T_j}\sum_{t=1}^{T_j} p_{jt}$, lagged 12 months (first introduced by Bhargava and Sargan (1983) and studied in Arellano and Bover (1995)). I also control for the existence of tariffs over imported cars.

Consistent estimators are obtained by first using the within transformation to remove the fixed effect and then applying two-stage least squares to the transformed model.

Table 5 summarizes estimation results. The coefficients of real price and characteristics have the expected sign and almost all of them are significant at the 1% level.

The own-price elasticities implied by the estimates of Table 5 suffer from the rigidity in substitution patterns imposed by the logit assumption. The nested logit helps in correcting the problem but the elasticities for cheaper cars are still small, a bit far from the pattern for the US automobile industry (Berry, Levinsohn, and Pakes (1995)), but at least not so far from previous estimates for European markets (Brenkers and Verboven (2006)). In facing the trade-off between accuracy and computational simplicity, the loss of precision at this stage might not be excessively harmful. Nested logit is still a common approach to demand estimation in automobile markets. The alternative would be to estimate demand following the BLP methodology.

Demand estimation yields the estimate of α and σ in equation (5) and the hedonic coefficients for characteristics, used in the construction of the index k.

Policy Functions Tables 6 and 7 summarize the probits for quality changes and the entry and exit policies. For entry, the coefficients are in general significant although their interpretation is not direct because we are interested in the reversed probability $\Pr(entry \mid N)$ and also because in ordered probit models the sign of the marginal effect does not always coincide with the sign of the coefficient for the intermediate categories. For exit, the interpretation varies depending on the segment considered, but in general the parameters are significant. Regarding the probit for investment, the probability of investing increases with the level of k and is decreasing in the distance to the mean. It seems that models with a large endowment of characteristics are modified more frequently and last longer than smaller cars. At the same time, cars that are "too different" from their competitors are more likely to quit and less likely to be modified.

I choose cubic B-splines because of their flexibility and computational simplicity. Splines are interpolation methods used to make predictions of a variable based on other(s) when the functional relation between them is not known. (see Judd (1998) chapter 6 or Cheney and Kinkaid (1985) chapter 7 for a survey). B-splines are defined with reference to a set of knots. A k-degree B-spline is just a set of different k-degree polynomials, one for each of the intervals defined by the set of knots. It has the property that the derivatives from 0 to $k-1$ at each knot are the same for contiguous polynomials. This produces smooth interpolations.

I use cubic B-splines with 20 interior knots to tabulate the investment policy function. I construct a grid for the explicative variable with precision 10^{-5} and then I compute the predicted value of investment for each element in the grid using the cubic B-splines. The tabulated policy stays in memory and it is called when a value for predicted investment is needed. The grid is fine enough as the explicative variable does not show significant variability further than the 4th or 5th decimal place. There is no particular economic interpretation to be given to those parameters, but they provide a good fit of the tabulated investment policy to the observed one.

Prices and market shares have no dynamic implication and are solved every period given the level of k . Unfortunately, there is no explicit analytical expression of p as function of k within the logit framework. Therefore, I again use cubic B-splines to obtain p as a tabulated function of k[5], $p_i = p_i(k_i)$.

In generating the simulated paths, a random shock or bias is added to each of the three policies. For entry and exit, I draw from a random uniform distribution. For investment, I draw from a lognormal distribution (in fact, this is as if it were a bias over the level of k; that's the reason for assuming log-normality). The cutoff values for entry, exit, and investment policies are also drawn from a uniform distribution, rescaled in each case to meet sample moments.

The simulation of the alternative paths goes as follows: I draw initial values for k from a lognormal distribution. With these initial values, I can use policy functions to obtain the correspondent price and exit decisions. Then I only have to recursively apply the policy functions until a whole history for all firms (incumbents and potential entrants) is filled up. I repeat the same process for the same initial state but this time adding a small random shock to the policies to simulate alternative, non-optimal paths. I do it for 132 periods (months). Given a simulated history, I can compute the market shares for each firm. Then I can compute the W_{ij} vector in equation (10) as the difference between the present discounted values from the actual and the alternative histories. The discount factor is the monthly equivalent of a 10% annual interest rate. During the 1990's, interest rates in Spain ranged from 3% in 2000 up to values close to 10% at the beginning of the decade. I stick to the conservative perspective.

[5] Alternatively, the first-order conditions could be solved numerically for p, at the cost of increasing the computational burden.

4.6.2 Estimates of Dynamic Parameters

The equilibrium condition (11) and its empirical counterpart can be constructed with the simulated histories. The minimization of (13) yields the vector of dynamic parameters for investment cost and scrap value. Table 8 provides estimates for the scrap value and investment cost parameters for the whole Spanish market. It turns out that scrap values are moderate compared to industry profits. The implied price elasticities combined with average prices in Table 4 yield margins roughly between 5000 and 8000 euros per car. This is equivalent to $5100 - 8200$ units. The scrap value in this context can be interpreted as what remains for a firm after it quits a model. For example, a successful car may induce consumers to go to that firm looking for the new model because of the positive image of the previous one. The sell-off value would be the value of the goodwill generated by the model quitting the market.

The parameters for investment cost reveal a small or moderate cost of changing characteristics. The large value of the coefficient is just an effect of the rescaling of investment. In fact, the changes in k are usually small (on average, in absolute value 0.18 with standard deviation 0.17) and magnitudes of 10^{-2} or much smaller are frequent. Continuing with the High-Intermediate segment, the investment cost of, for example, a change of 0.02 in k is 1 million € or, equivalently, the profits from selling just $130 - 210$ units.

Before discussing the results on entry cost, a word on the way they are computed may be useful. I compute the EDV of introducing a product when the firm has no other product (thus this is firm entry) and when the firm has up to five products. In the latter case, previous products are always in different segments than the one the firm is currently entering (thus this is segment entry). I do this for each segment. For example, I compute the EDV of entering segment 1 (the same for all other 7 segments) when the firm has no previous product in segment one, and when it has one product in another segment. In this latter case, there are 7 alternative situations (the previous product being in each of the 7 remaining segments). Finally, each of the alternative situations of entry described above is computed under different industry structures,i.e., for alternative numbers of rival products in the segment of entry. For example, I compute de EDV of firm one introducing its second product in segment 1 when its first product is in segment 6 and the number of rival products in segment 1 (the segment of entry) is 5. I do this for all the combinations of: 1) segments; 2) the number of previous products in different segments (up to five); 3) the number of rival products in the segment of entry. It is easy to see that the number of alternative starting states becomes large as we allow for diversity: with 8 segments, allowing for five previous products at most and considering only 4 alternative numbers of competing products, we have 3840 different initial states $(8 \times (1+7+21+35+35+21) \times 4)$. The initial states described above are generated randomly. In the segment of entry and in the starting period, all firms are forced to have only one product (they may introduce new products from period two onwards). In all other segments, there is no constraint. For the entering firm, and in the case it is allowed to have 2 or more previous products, these are forced to be in different segments. This is to reduce the number of possible alternative combinations.

Once the alternative initial states are devised, the usual forward simulation procedure is used to compute the EDV of the product that has been introduced. The EDV's are normalized such that they have variance 1. The empirical probability of entry is computed using the policy function. The variable accounting for the number of previous models is also easily obtained. All of this allows the estimation of (14).

The distribution of entry costs has a mean of $2,439$ million euros. In terms of units of product, this is roughly equivalent to $304,000$ to $487,000$ units. Although this may look large, it has to be taken into account that it corresponds to the cost of entry of a firm for the first time. Once the firm is established and operating in a given segment, the introduction of a second model in another segment is substantially cheaper: the cost of entering a second product in a different segment is equivalent to $271,000 - 433,000$ units, 12.5% less. Entry costs remain low for the range of products between 2 and 4 and tend to rise again with 5 products. These estimates seem reasonable compared to the $10,000$ units per model sold on average every year and the $50,000$ units per year for the most popular models of different firms.

So far, I have not computed standard errors for the dynamic parameters. I plan to do it using non-parametric bootstrap which is robust to sampling error introduced in the first stage of estimation or induced by the simplification of the state space.

The results show that there exist economies of scope in commercialization and that these economies tend to disappear as the profile of a firm's product goes large (Figure 1). Once a firm has entered the market, it has incentives to expand its range of products. However, when the firm has products in 4 different segments, starting to cover a fifth segment does not turn out to be so cheap. It is easy to see the implications in the automobile industry: we can see firms covering a wide range of products, but not the full range of products because, as the results suggest, it is too costly. Citroen may have a good profile of products in the low and medium-quality segments but producing in all segments would imply it is also producing high-quality cars, and it may not be prepared for that. On the other side, Mercedes Benz can be good in luxury and sports cars but very bad in less expensive ones.

This suggests that some advantages can be obtained, among others, in the process of commercialization and distribution, and not only at the productive plant level (whose analysis is beyond the scope of this paper). It also provides an explanation for the dramatic increase in the number of models for sale in the Spanish market during the 1990's.

4.7 Concluding Remarks

This chapter presents a dynamic model of entry and exit for the Spanish car industry that allows the computation of entry costs in different scenarios. In particular, it permits the comparison between the cost of firm entry, understood as the cost of introducing the first product, and the cost of introducing a second and further models. This difference gives a measure of the scope economies in commercialization, and a quantification of the advantages of being an incumbent when a firm is about to introduce new products. The estimation strategy is based on the methodology proposed by Bajari, Benkard, and Levin (2007). The results show that entry costs are moderate and that there is a substantial reduction in the cost of introducing a second product with respect to the introduction of the first product. The advantage extends to the third, fourth, and fifth product and seems to be exhausted when the firm wants to introduce a sixth one. This gives support to the idea of firms having an optimal number of products and can also explain product proliferation in the automobile industry.

There are some issues that call for future work. Firstly, a more flexible approach to demand estimation may help to obtain better estimates of price elasticities, in line with Berry, Levinsohn, and Pakes (1995). Secondly, the paper shows results for entry costs in different segments, but the same framework can be used to compute the costs of introducing the second, third, etc. product in the same segment. This would provide a measure of the advantages of incumbent firms in product replacement by opposition to newcomers. In third place, standard errors for the estimated parameters are needed. The most suitable technique seems to be the bootstrap, even if it makes the problem more computationally burdensome. Finally, the model should be extended to account for a previous development stage where the products are technically devised before it is decided whether they will be introduced or not.

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Appendix: Pricing Equations and Profit Functions in Nested Logit

Consider a multiproduct firm i facing nested logit demand and competing in prices. Its objective function is:

$$\pi_i = \sum_{g\in G}\sum_{j\in G_g} (p_j - c_j)\, S_j M$$

where M is market size and g is segment from the total number of segments G. Also: $S_{j/g}$ is the share of product j in group g, $S_{ig} = \sum_{j\in G_g} S_j$, $S_{i/g} = \sum_{j\in G_g} S_{j/g}$ is the share of firm i in segment g, and $S_g = \sum_{g\in G}\sum_{k\in G_g} S_k$ is the share of group g, such that $S_j = S_g * S_{j/g}$.

The FOC for the maximization problem of a multiproduct firm (several products in several segments) under Nested Logit demand is:

$$\begin{aligned}(p_j - c_j)\, S_j \;=\;& \frac{1-\sigma_g}{\alpha_g} S_j + \sigma_g S_{j/g} \sum_{j\in G_g} (p_j - c_j)\, S_j \\ &+ (1-\sigma_g)\, S_j \sum_{g\in G}\sum_{j\in G_g} (p_j - c_j)\, S_j \quad , \quad \forall j \;,\; \forall g \end{aligned} \tag{16}$$

Divide by S_j and rearrange $S_{j/g}$:

$$(p_j - c_j) = \frac{1-\sigma_g}{\alpha_g} + \sigma_g \sum_{j\in G_g} (p_j - c_j)\, S_{j/g} + (1-\sigma_g) \sum_{g\in G}\sum_{j\in G_g} (p_j - c_j)\, S_j \quad , \quad \forall j \;,\; \forall g$$

The three summands on the right hand side are equal for all products within the same segment, but different across segments. Therefore, we can take $(p_j - c_j)$ out of within-segment summations:

$$(p_j - c_j) = \frac{1-\sigma_g}{\alpha_g} + \sigma_g (p_j - c_j) S_{i/g} + (1-\sigma_g) \sum_{g \in G} (p_j - c_j) \sum_{j \in G_g} S_j \ , \ \forall j \ , \forall g \quad (17)$$

Now go back to (16), multiply by M and sum over g and j:

$$\begin{aligned} \sum_{g \in G} \sum_{j \in G_g} (p_j - c_j) S_j M &= M \sum_{g \in G} \frac{1-\sigma_g}{\alpha_g} S_{ig} + M \sum_{g \in G} \sigma_g (p_j - c_j) S_{ig} S_{i/g} \\ &+ \left(\sum_{g \in G} \sum_{j \in G_g} (p_j - c_j) S_j M \right) \sum_{g \in G} (1-\sigma_g) S_{ig} \end{aligned}$$

$$\pi_i^{var} = M \sum_{g \in G} \frac{1-\sigma_g}{\alpha_g} S_{ig} + M \sum_{g \in G} \sigma_g (p_j - c_j) S_{ig} S_{i/g} + \pi_i^{var} \sum_{g \in G} (1-\sigma_g) S_{ig} \quad (18)$$

Take (16) and sum over j:

$$\begin{aligned} \sum_{j \in G_g} (p_j - c_j) S_j &= \frac{1-\sigma_g}{\alpha_g} S_{ig} + \sigma_g (p_j - c_j) S_{ig} S_{i/g} \\ &+ \left[(1-\sigma_g) \sum_{g \in G} \sum_{j \in G_g} (p_j - c_j) S_j \right] S_{ig} \ , \quad \forall g \end{aligned}$$

$$\begin{aligned} \sum_{j \in G_g} (p_j - c_j) S_j &= \frac{1}{1-\sigma_g S_{i/g}} \frac{1-\sigma_g}{\alpha_g} S_{ig} \\ &+ \frac{1}{1-\sigma_g S_{i/g}} \left[(1-\sigma_g) \sum_{g \in G} \sum_{j \in G_g} (p_j - c_j) S_j \right] S_{ig} \ , \forall g \quad (19) \end{aligned}$$

Substitute back in (18):

$$\begin{aligned}\pi_i^{var} &= M\sum_{g\in G}\frac{1-\sigma_g}{\alpha_g}S_{ig}+\sum_{g\in G}\sigma_g S_{i/g}\left[\frac{\frac{1-\sigma_g}{\alpha_g}S_{ig}}{1-\sigma_g S_{i/g}}M+\frac{\left(1-\sigma_g\right)\pi_i^{var}\left(S_{ig}\right)}{1-\sigma_g S_{i/g}}\right]\\ &+\pi_i^{var}\sum_{g\in G}\left(1-\sigma_g\right)S_{ig}\end{aligned}$$

$$\begin{aligned}\pi_i^{var} &= M\sum_{g\in G}\frac{1-\sigma_g}{\alpha_g}S_{ig}+\sum_{g\in G}\sigma_g S_{i/g}\frac{\frac{1-\sigma_g}{\alpha_g}S_{ig}}{1-\sigma_g S_{i/g}}M\\ &+\pi_i^{var}\sum_{g\in G}\sigma_g S_{i/g}\frac{\left(1-\sigma_g\right)S_{ig}}{1-\sigma_g S_{i/g}}+\pi_i^{var}\sum_{g\in G}\left(1-\sigma_g\right)S_{ig}\end{aligned}$$

$$\begin{aligned}\left[1-\sum_{g\in G}\sigma_g S_{i/g}\frac{\left(1-\sigma_g\right)S_{ig}}{1-\sigma_g S_{i/g}}-\sum_{g\in G}\left(1-\sigma_g\right)S_{ig}\right]\pi_i^{var} &= M\sum_{g\in G}\frac{1-\sigma_g}{\alpha_g}S_{ig}\\ &+\sum_{g\in G}\sigma_g S_{i/g}\frac{\frac{1-\sigma_g}{\alpha_g}S_{ig}}{1-\sigma_g S_{i/g}}M\end{aligned}$$

$$\left\{1-\sum_{g\in G}\left[\frac{\sigma_g S_{i/g}\left(1-\sigma_g\right)S_{ig}+\left(1-\sigma_g\right)S_{ig}-\sigma_g S_{i/g}\left(1-\sigma_g\right)S_{ig}}{1-\sigma_g S_{i/g}}\right]\right\}\pi_i^{var}=$$
$$= M\sum_{g\in G}\frac{\left(1-\sigma_g S_{i/g}\right)\frac{1-\sigma_g}{\alpha_g}S_{ig}+\sigma_g S_{i/g}\frac{1-\sigma_g}{\alpha_g}S_{ig}}{1-\sigma_g S_{i/g}}$$

$$\left\{1-\sum_{g\in G}\left(\frac{\left(1-\sigma_g\right)S_{ig}}{1-\sigma_g S_{i/g}}\right)\right\}\pi_i^{var}=M\sum_{g\in G}\frac{\frac{1-\sigma_g}{\alpha_g}S_{ig}}{1-\sigma_g S_{i/g}}$$

Then $\pi_i^{var}=f\left(\sigma_g,\alpha_g,S_j,S_{j/g},M\right)$. Rearrange (19) using the definition of π_i^{var}:

$$\sum_{j\in G_g}(p_j - c_j)\,S_jM = \frac{\frac{1-\sigma_g}{\alpha_g}S_{ig}}{1-\sigma_g S_{i/g}}M + \frac{(1-\sigma_g)\,S_{ig}}{1-\sigma_g S_{i/g}}\pi_i^{var} \quad , \quad \forall g$$

$$\pi_{ig}^{var} = \frac{\frac{1-\sigma_g}{\alpha_g}S_{ig}}{1-\sigma_g S_{i/g}}M + \frac{(1-\sigma_g)\,S_{ig}}{1-\sigma_g S_{i/g}}\pi_i^{var} \quad , \quad \forall g$$

Now go back to (16):

$$(p_j - c_j)\,S_jM = \frac{1-\sigma_g}{\alpha_g}S_jM + \pi_{ig}^{var}\sigma_g S_{j/g} + \pi_i^{var}(1-\sigma_g)\,S_j \quad , \quad \forall j \ , \ \forall g$$

Then:

$$\pi_j^{var} = \frac{1-\sigma_g}{\alpha_g}S_jM + \pi_{ig}^{var}\sigma_g S_{j/g} + \pi_i^{var}(1-\sigma_g)\,S_j \quad , \quad \forall j \ , \ \forall g$$

where π_{ig}^{var} and π_i^{var} are the functions of market shares computed above.

Tables

Table 1

Charac.:	Description	% of variation (year)	% of variation (month)
CCKg	Cubic centimeters by kilo	50.0%	3.8%
CarSize	Length times width (m^2)	36.9%	2.8%
KmL	Kilometers driven by litre	47.7%	3.5%
Maxsp	Maximum speed in Km/H	43.7%	3.1%
AC	Air conditioning	27.3%	2.3%
ABS	ABS	25.6%	2.1%
Overall		59.9%	4.8%

Table 2

% of monthly							Overall		
variation	CCKG	CarSize	Kml	MaxSp	AC	ABS	%	# changes	# obs.
Small-Mini	2.2	2.0	2.7	2.0	1.9	1.7	3.2	19	587
Small	3.7	3.0	3.5	3.1	2.0	1.6	5.2	120	2310
Compact	3.7	2.8	3.7	3.3	2.4	2.1	5.0	147	2,959
Intermediate	3.7	3.0	3.9	3.4	2.7	2.8	5.1	75	1,480
High Interm.	3.8	2.8	3.3	3.0	2.5	2.0	4.6	146	3144
Luxury	3.7	2.6	3.4	3.0	1.6	1.8	4.4	141	3191
Sport	3.9	2.6	3.2	2.9	1.9	2.2	4.5	66	1,475
Minivan	4.9	3.5	3.9	3.4	3.9	3.0	6.1	74	1216
Overall	3.8	2.8	3.5	3.1	2.3	2.1	4.8	788	16362

Table 3

	Entry (%)		Exit (%)		Av. #models
	Monthly	Yearly	Monthly	Yearly	
Small-Mini	1.2	13.2	0.9	9.4	4.6
Small	1.0	11.2	0.6	6.8	17.4
Compact	1.1	12.7	0.7	8.2	23.2
Intermediate	1.2	13.3	1.3	14.1	11.6
High Intermediate	0.9	10.2	0.4	4.4	24.8
Luxury	0.8	8.5	0.4	5.0	24.2
Sport	1.2	13.7	0.6	6.9	11.8
Minivan	2.3	25.2	0.2	2.7	16.7
Overall	1.1	12.3	0.6	6.7	19.6

Table 4

Mean Characteristics:	CCKG	CarSize	Kml	MaxSp	AC (%)	ABS (%)	Horse Power	Real Price (€)
Small-Mini	1.355	5.321	20.9	143.6	0.5	0.0	48.8	6,301
Small	1.480	5.904	19.9	158.0	5.5	0.4	64.2	7,377
Compact	1.526	6.962	18.0	181.7	19.6	15.5	97.9	11,491
Intermediate	1.600	7.515	17.0	187.8	42.8	25.9	109.3	13,894
High Interm.	1.538	7.664	16.0	199.0	56.5	49.3	124.6	16,877
Luxury	1.711	8.497	14.1	213.6	86.3	75.5	165.9	27,272
Sport	1.768	7.592	14.9	217.6	88.4	78.0	170.2	27,519
Minivan	1.428	7.931	13.7	175.7	66.4	39.8	123.7	19,772
Overall	1.573	7.367	16.5	189.9	48.8	39.4	119.2	17,114

Table 5: Demand estimation

Fixed effects (within) IV regression		Coefficient	Std. Dev.
Real price coefficients:			
	Small-Mini	-0.053	0.057
	Small	-0.051^{**}	0.026
	Compact	-0.136^{***}	0.015
	Intermediate	-0.124^{***}	0.021
	High Intermediate	-0.094^{***}	0.012
	Luxury	-0.064^{***}	0.007
	Sport	-0.155^{***}	0.011
	Minivan	-0.067^{***}	0.016
Intra-Group correlation:			
	Small-Mini	0.777^{***}	0.025
	Small	0.792^{***}	0.034
	Compact	0.739^{***}	0.025
	Intermediate	0.742^{***}	0.022
	High Intermediate	0.367^{***}	0.035
	Luxury	0.948^{***}	0.028
	Sport	0.707^{***}	0.033
	Minivan	0.099^{***}	0.026
Characteristics:			
	Car Size	0.201^{***}	0.022
	HP	0.009^{***}	0.0005
	KmL	0.004	0.004
	Air Conditioning	0.042^{***}	0.016
	ABS	0.178^{***}	0.016
Controls:			
	Tariffs	0.049^{***}	0.002
	Constant	-9.879^{***}	0.219

(*,**,***, significant at 10%, 5%, 1%)

Table 6: Entry policy function

	$Pr\,(N \mid entry)$	$Pr\,(N \mid no\ entry)$
Average k by seg.	0.175	0.417
	(0.150)	(0.015)
#models other seg.	1.282	1.165
	(0.086)	(0.008)
cutoff 1	0.205	1.143
	(0.508)	(0.052)
cutoff 2	1.618	2.192
	(0.477)	(0.050)
cutoff 3	2.960	3.340
	(0.494)	(0.051)
cutoff 4	4.389	4.733
	(0.530)	(0.054)
cutoff 5	5.401	5.699
	(0.561)	(0.058)
cutoff 6	6.473	6.903
	(0.591)	(0.062)
cutoff 7	7.710	7.790
	(0.636)	(0.065)
cutoff 8	9.052	8.760
	(0.732)	(0.072)
cutoff 9	9.803	9.241
	(0.781)	(0.076)
cutoff 10	10.890	10.498
	(0.858)	(0.086)
cutoff 11	12.256	10.952
	(1.062)	(0.090)
Observed rate of entry:		0.011

Table 7: Policy functions

	Small-Mini	Small	Compact	Intermediate	High Interm.	Luxury	Sport	Minivan
Probit of exit								
constant	−2.809	−2.619	−2.733	−3.022	−2.602	−2.769	−2.474	−2.962
	(0.325)	(0.179)	(0.159)	(0.269)	(0.163)	(0.218)	(0.212)	(0.356)
# of firm models in seg	0.562	0.303	0.205	0.027	0.046	−0.254	−0.035	0.161
	(0.387)	(0.157)	(0.077)	(0.122)	(0.139)	(0.122)	(0.286)	(0.236)
age of firm oldest model	0.002	−0.001	0.001	0.010	−0.001	0.003	−0.0004	0.001
	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.0018)	(0.005)
dev. of k wrt its seg mean	0.341	−1.330	−0.635	−0.656	−0.198	0.033	−0.119	−0.212
	(1.827)	(0.726)	(0.372)	(0.386)	(0.388)	(0.274)	(0.234)	(0.443)
Probit for investment								
constant	−0.033	−9.235	−5.168	−7.986	−5.415	−2.993	−3.529	−6.618
	(3.889)	(3.436)	(1.314)	(2.341)	(1.055)	(1.600)	(1.480)	(2.635)
k	−1.291	3.941	1.360	2.288	1.231	0.328	0.483	1.651
	(2.418)	(1.830)	(0.539)	(0.873)	(0.363)	(0.459)	(0.440)	(0.902)
dev. of k wrt its seg mean	1.300	−4.659	−1.183	−2.531	−1.511	−0.368	−0.533	−1.956
	(2.680)	(1.889)	(0.572)	(0.910)	(0.400)	(0.465)	(0.452)	(0.914)

Table 8: Dynamic Parameters

(Unit: millions of Euros)	Coefficient	Economy (%)
Investment cost parameter	-52.751	
Scrap value	41.149	
Mean firm entry cost	$2,439.805$	
Mean entry cost with:		
1 product	$2,168.118$	12.5
2 products	$2,218.291$	10.0
3 products	$2,240.368$	8.9
4 products	$2,229.832$	9.4
5 products	$2,330.066$	4.7

Figure 1: Mean entry cost by number of products.